AGRICULTURAL ENGINEERING

JULY • 1954

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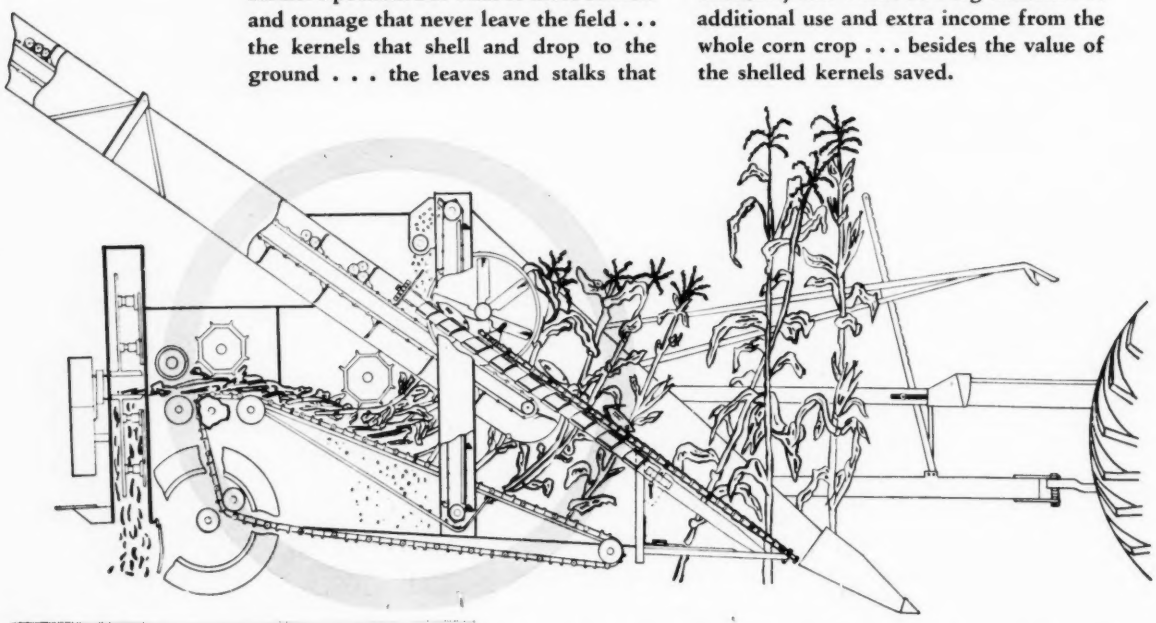
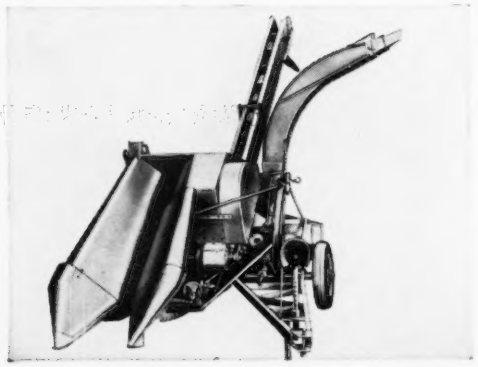
Practical Method of Measuring Water Flow from Gated Pipe

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Saves THE LOST BUSHELS

Only that part of the corn crop that's either sold or fed puts money in the farmer's pockets. But what of those bushels and tonnage that never leave the field . . . the kernels that shell and drop to the ground . . . the leaves and stalks that could make dry roughage, low-cost silage . . . excellent bedding? Salvage of this part ordinarily lost would be a big windfall . . . additional use and extra income from the whole corn crop . . . besides the value of the shelled kernels saved.

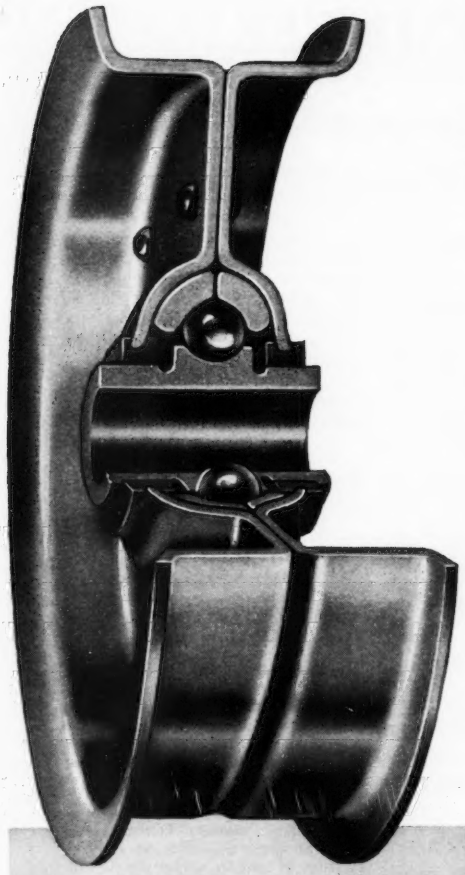




That's why Case dug deep to serve, to give farmers a way of full use of their corn crop. Via the routes of research and design, Case engineers have developed a machine that saves bushels per acre, the loss usually incurred by mechanical picking. Kernels ordinarily lost going through picking rolls drop to a floor underneath the stalkway. A chain rake, in turn, delivers them to the elevator where they join the ears on the way to the wagon. The drawing above and the photo to the left show this new, shielded feature.

There's an equally great crop-salvage feature, one that provides a new kind of bonus to cost-conscious farmers. In the same operation of picking, the Case Corn Harvester chops or shreds stalks and leaves. In terms of crop savings, it takes tough vegetation . . . cuts it into desired lengths and blows it into a forage wagon for low-cost, filling feed or absorbent bedding. For those who prefer, it chops or shreds stalks into fine material . . . returns it direct to the ground for rapid decay, also making plowing and disking much easier and faster. At left is the Corn Harvester equipped to deliver chopped stover into trucks or wagons. J. I. Case Co., Racine, Wis.

CASE



BCA

IDLER PULLEY ASSEMBLY

gives outstanding performance on Minneapolis-Moline Uni-Farmor

The BCA Idler Pulley is a *package unit* specifically designed for agricultural use. This benefits both the equipment manufacturer and the farmer. Because pulley and bearing are combined in a single unit, installation problems are simplified. The farmer has no field-servicing problem because the pre-lubricated bearing is effectively sealed against dust and grit.

The BCA Idler Pulley is adaptable to many agricultural applications: combines, hay balers, forage harvesters, grain elevators, corn and cotton pickers, spreaders. Sheave design can be varied for use with flat belts, V-belts, or chains. BCA engineering cooperation and design assistance can help *you* solve problems involving ball bearings.

"We have found that this idler pulley bearing, as used in our Uni-Picker-Sheller, has proved itself and is giving outstanding performance on this machine."

LES E. PETTER
Assistant to the chief engineer
Farm Machinery Division
Minneapolis-Moline Company

Here's the Minneapolis-Moline Uni-Picker-Sheller in action. Cut-away above shows the construction of the BCA Idler Pulley used on this unit.

BCA *radial, thrust angular-contact Ball Bearings*

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AGRICULTURAL ENGINEERING

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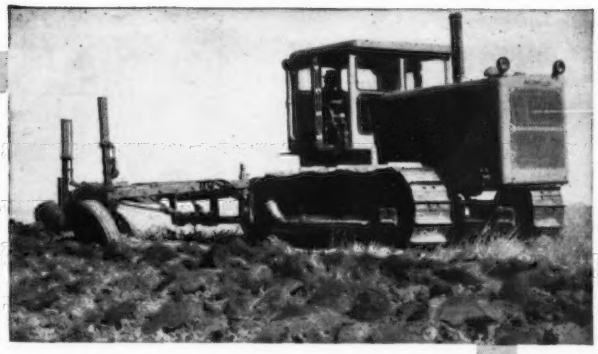
DEEP TILLAGE BRINGS HOPE TO DROUGHT-DISASTER AREAS



Bone dry, burned out, baked "hard as a brick," Texas land will turn green again next spring, even with less than normal rainfall.

Caterpillar Farm Tractors hauling giant disk plows are slashing their way through packed, drought-disaster land to condition the soil 14"-16"-18" deep for wheat, cotton, or range. This will speed up crop growth and range improvement. Land where grass roots *have died* will carry cattle in a year or so. Sandy soil will be turned and tied down to stop a 1954 "Dust Bowl".

Leading the deep tillage attack are Caterpillar Diesel Tractors . . . the one tractor with the guts to take the punishment of 24 hour, full load work, year after year.

Proof of long life comes from the many Cat® Diesel Tractors that have worked for 50,000 or more actual field hours. The longest work record ever reported for a farm tractor is held by a Cat Diesel Tractor that has actually worked more than 80,000 hours . . . equal to 100 years of service on the average farm!

Big scale deep tillage has to be done cheaply to break even . . . Caterpillar Diesel Tractors work for 60% to 80% less fuel cost than ordinary gasoline wheel tractors. Up to 32,900 pounds of pull on the drawbar, so Caterpillar owners accomplish far more work than they can with wheel tractors.

On the burned out Texas plains . . . as elsewhere . . . farmers are turning to the most efficient farm tractors, capable of helping to produce bigger yields at less cost . . . with less labor. That's the job tailor-made for a Cat Diesel Tractor!

Caterpillar Tractor Co., Peoria, Illinois

CATERPILLAR®

DIESEL FARM TRACTORS

want high speed plus endurance? How's this...

1000 HOURS at 3600 R.P.M. UNDER FULL LOAD!

If you were to drive 90,000 miles up an incline at 90 m.p.h., you would approximate the performance of the Model 24A, 331 cubic inch displacement Chrysler Industrial Engine pictured below.

To prove the power of Chrysler Industrial V8 Engines . . . their ability to run for long periods of time at high speed . . . on March 17, 1954 Chrysler engineers placed a production model Ind. 24A Engine on an endurance dynamometer at Chrysler Central Engineering Laboratories. Objective: 1000 hours operation at 3600 R.P.M. under full load.

During every one of the 1000 hours, the Chrysler Ind. 24A Engine delivered an average of 174 horsepower and when shut down, the engine was still in perfect operating condition.

During the run no service was necessary beyond minor maintenance care, such as oil changes and very infrequent spark plug changes and point adjustment. Yet, following disassembly of the engine, the only wear noted was negligible—no more than you might expect from an engine that has been operated for 1000 hours within a long period of time.

While there is every reason to believe that this is a record-breaking endurance run (and don't forget it was made at 3600 R.P.M. under full load), we are confident that every Chrysler Industrial V8 Engine will *at least equal* this astounding record.

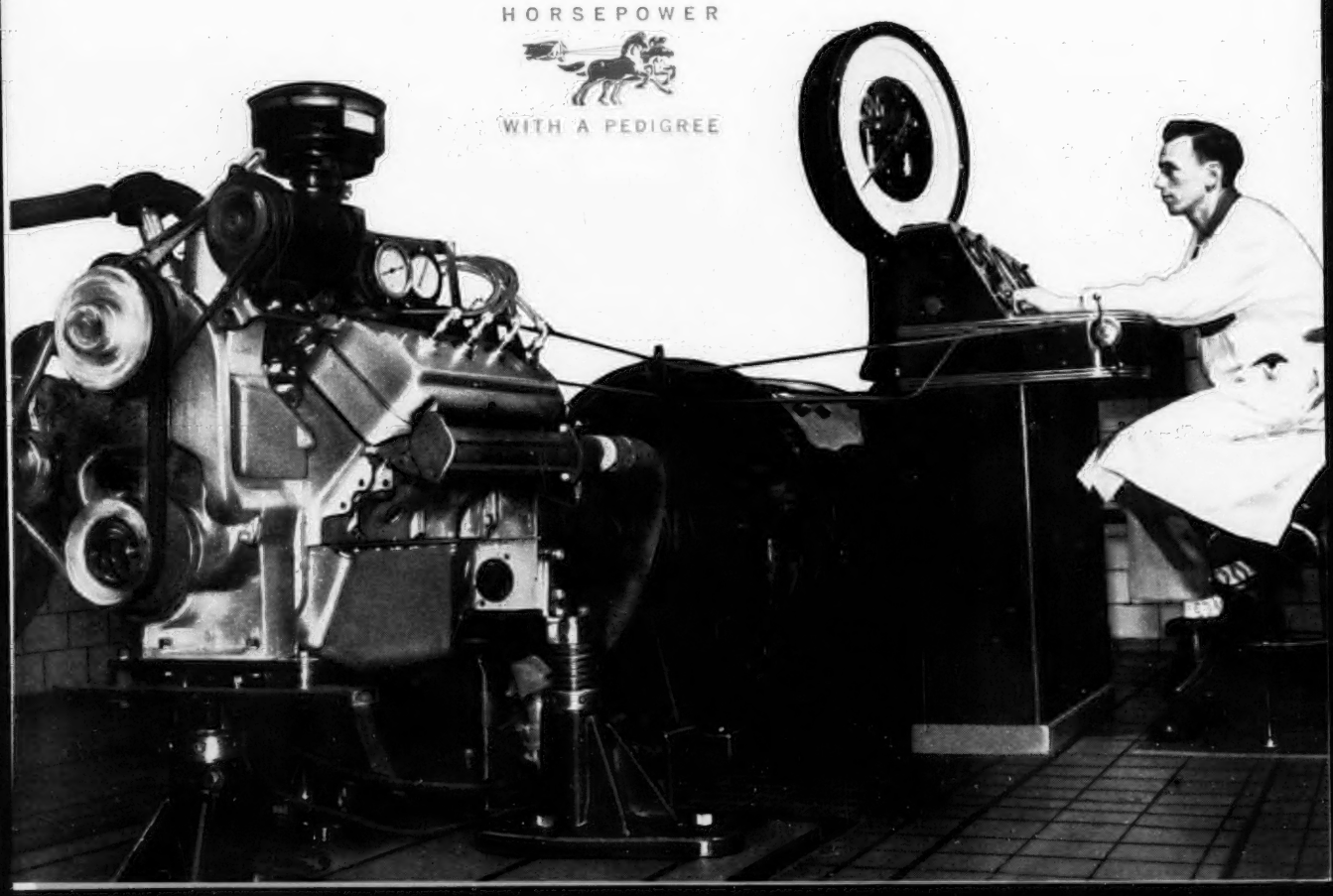
This proves too, beyond a doubt, that the Chrysler Industrial V8 hemispherical combustion chamber design with its short-stroke, low-friction construction, makes an ideal power plant for any equipment that requires continuous high speed operation. Furthermore, in installing a Chrysler V8 Engine in preference to a diesel engine of similar horsepower, you can reduce your size estimate by one-half, your weight by two-thirds, and your cost factor by three-quarters!

For detailed information on the Model 24A or any Chrysler Industrial Engine, see a Chrysler Industrial Engine Dealer, or write: ***Dept. 167, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

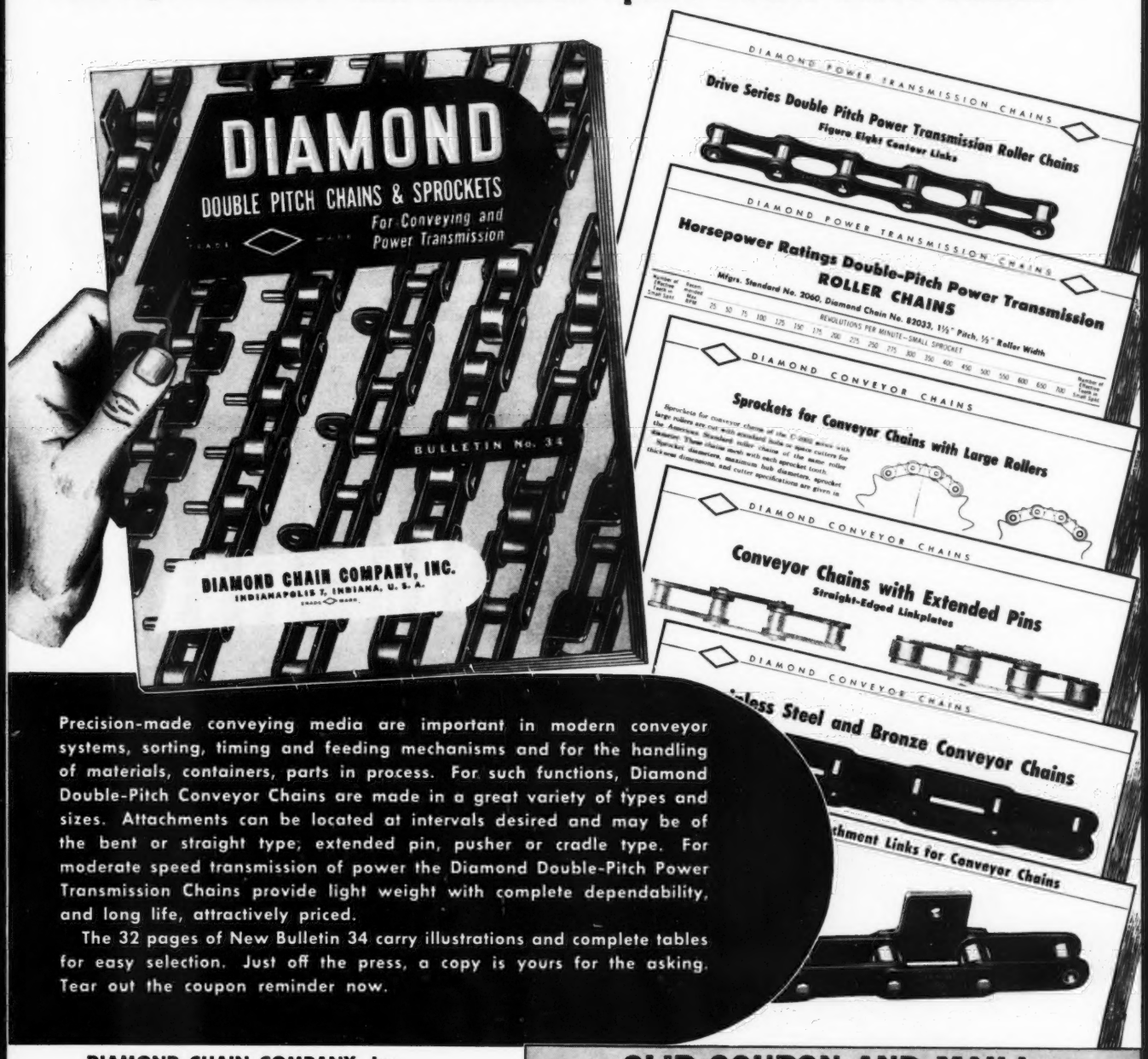
CHRYSLER *Industrial Engines*

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

HORSEPOWER WITH A PEDIGREE



NEW BULLETIN 34 Simplifies Selection of Conveyor Chains and Moderate Speed Power Drive Chains


DIAMOND
DOUBLE PITCH CHAINS & SPROCKETS
For Conveying and Power Transmission
BULLETIN No. 34
DIAMOND CHAIN COMPANY, INC.
INDIANAPOLIS 7, INDIANA, U. S. A.
DIAMOND POWER TRANSMISSION CHAINS
Drive Series Double Pitch Power Transmission Roller Chains
Figure Eight Contour Links
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DIAMOND CONVEYOR CHAINS
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DIAMOND CONVEYOR CHAINS
Conveyor Chains with Extended Pins
Straight-Edged Linkplates
DIAMOND CONVEYOR CHAINS
Bronze Conveyor Chains
Links for Conveyor Chains

Precision-made conveying media are important in modern conveyor systems, sorting, timing and feeding mechanisms and for the handling of materials, containers, parts in process. For such functions, Diamond Double-Pitch Conveyor Chains are made in a great variety of types and sizes. Attachments can be located at intervals desired and may be of the bent or straight type; extended pin, pusher or cradle type. For moderate speed transmission of power the Diamond Double-Pitch Power Transmission Chains provide light weight with complete dependability, and long life, attractively priced.

The 32 pages of New Bulletin 34 carry illustrations and complete tables for easy selection. Just off the press, a copy is yours for the asking. Tear out the coupon reminder now.

DIAMOND CHAIN COMPANY, Inc.
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Please refer to the classified section of your local telephone directory under the heading CHAINS OR CHAINS-ROLLER

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Farmers get top performance from their trucks, tractors and heavy-duty equipment with this new plug because:

EXTRA-BIG ELECTRODES—give extra miles of long, dependable service without constant regapping and cleaning.

RUGGED CONSTRUCTION—helps withstand the heavy shocks and abuses from the most severe farm operation.

AIRCRAFT TYPE INSULATOR—the finest material ever developed—resists high temperatures—plugs stay clean even under idling or other "cold engine" conditions.

WIDEST HEAT RANGE—assures peak efficiency through widest range of operating conditions from heavy pull to light idling.

Original factory equipment on many leading makes of trucks and tractors. Remember, Auto-Lite is a complete spark plug line.

AUTO-LITE "STA-FUL" BATTERY FOR TRACTORS

Now available! A newly designed "Sta-ful" Battery especially built for tractors, light trucks and other off-the-road machinery. Auto-Lite "Sta-ful" needs water only 1/3 as often in normal tractor use. New rugged case withstands heavy shocks . . . Fibre-glass insulation gives longer life . . . extra liquid reserve protects battery plates to save customers time and worry. Auto-Lite is a complete battery line—specified as original equipment for many leading makes of cars, trucks and tractors.

ORIGINAL

AUTO-LITE WIRE AND CABLE

Auto-Lite is a complete line—featuring sensational new Neosheath Spark Plug Wire that keeps plugs dry, famous Flextrand Primary Wire that is easier to install, Auto-Lite Battery Cable with the new Power-Line Terminal that holds tight. All three used as original factory equipment.

AUTO-LITE BULL'S EYE SEALED BEAM UNIT

The new Auto-Lite Bull's Eye Lamp concentrates the stray light into the main driving beam. Factory focused and sealed under 9000 pounds per square inch pressure, the new lamp will operate even when lens is cracked or broken. Original factory equipment on many leading makes of cars and trucks.

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Coils, distributors, generators, starting motors, voltage regulators, and all other important parts of the electrical system are engineered by Auto-Lite to fit together and work together as a perfect team. Quality tested for unfailing dependability. Original factory equipment on many makes of cars, trucks and tractors.

ONE OR MORE AUTO-LITE ELECTRICAL UNITS ARE USED ON FARM EQUIPMENT MANUFACTURED BY

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Earthmaster
Centaur
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EQUIPMENT

The Key to bigger profits for Farm Equipment Dealers

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THE ELECTRIC AUTO-LITE COMPANY
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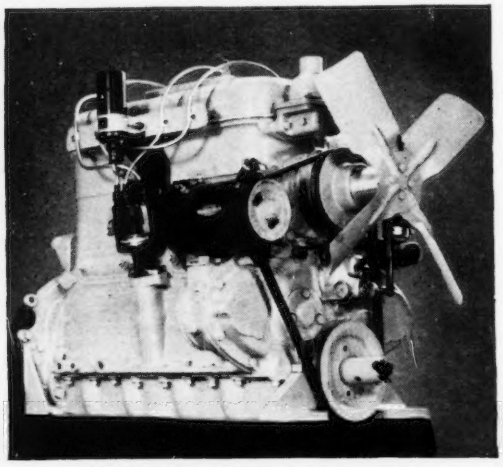
Minneapolis-Moline

NEW XO-121 BREAKS ALL RECORDS FOR TRACTOR-ENGINE EFFICIENCY

Experimental engine shows how high-compression engines can step up performance of farm tractors

Oliver Corporation has recently taken the wraps off an amazing experimental tractor engine that signals a new era in the development of farm power. This new engine delivers 44% more power than a typical high-performance engine.



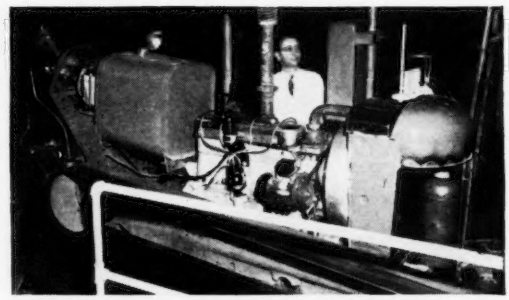
The most efficient tractor engine ever built.

Dynamometer tests in the laboratory showed 16.07 hp hours per gallon of fuel (operating maximum). This figure represents a specific fuel consumption of .385 lbs. per brake hp-hour, proving the experimental *XO-121 the most efficient tractor engine ever built.* And although it is not scheduled for production, its more efficient, flexible power and greater fuel economy will have a marked effect on the design of future tractor engines. For it clearly shows the benefits farmers can expect from high-compression engines using high-octane gasoline.

Secret of the new engine's outstanding performance and fuel saving is a 12 to 1 compression ratio that wrings a terrific amount of work out of high-octane gasoline. Otherwise, the XO-121's specifications are not unusual. Most of its parts are the same as those you see on conventional units. It has four cylinders with a bore and stroke of 3¾ by 4½, a displacement of 199 cubic inches, and a governed speed of 1600 rpm. Other features include overhead valves, a 12-volt ignition system and a highly efficient combustion chamber.

Because of its wide knowledge of the relationship of fuels and engines, Ethyl's research laboratory was chosen to assist in designing and testing the XO-121 and to work out the fuel for it. This is by no means a "trick" gasoline, however. It's a blend of commercially available high-octane components plus "Ethyl" antiknock compound.

While the XO-121 engine is a tremendous stride forward, it is only one step in a program to improve farm-tractor performance through



Laboratory tests to measure belt horsepower.

utilization of improved gasolines. You'll never see this engine on a farm. But the knowledge gained from the XO-121 will mean better performance and greater economy in tomorrow's farm tractors.

ETHYL CORPORATION
New York 17, N. Y.

Keep This View
Out of Your Picture
MECHANICS Roller Bearing UNIVERSAL JOINTS will give *your* trucks *more road time* and *less shop time* because MECHANICS JOINTS are specially designed with less parts and connections — for *easy assembly* and *servicing* — *smooth running balance* — *maximum strength* with *less weight* — and *long, trouble-free, safe operation.*
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Roller Bearing
UNIVERSAL
JOINTS
For Cars, Trucks, Tractors, Farm Implements, Road Machinery, Industrial Equipment, Aircraft

New Holland equips New Super "77" Baler with Dayton V-Belts

New Super "77" baler, developed by New Holland Machine Co., New Holland, Pa., employs 5 Dayton V-Belts to set 12-ton-an-hour record

Here's a baler designed for the farmer or custom operator who needs or wants increased capacity. Fully equipped with Dayton V-Belts, the Super "77" averaged an unprecedented *12 tons an hour* in carefully timed runs on private farms. Under good to ideal conditions even higher tonnage has been recorded.

Powered by a new VF-4, 24 HP, four-cylinder, air-cooled engine mounted well up out of the dust area, the baler is equipped with four perfectly matched Dayton B-Section V-Belts on a serpentine-type drive. This is a V-Flat drive and the back side of the belts are driven directly on the outside diameter of the Baler flywheel. Clutching action is achieved by a movable idler pulley.

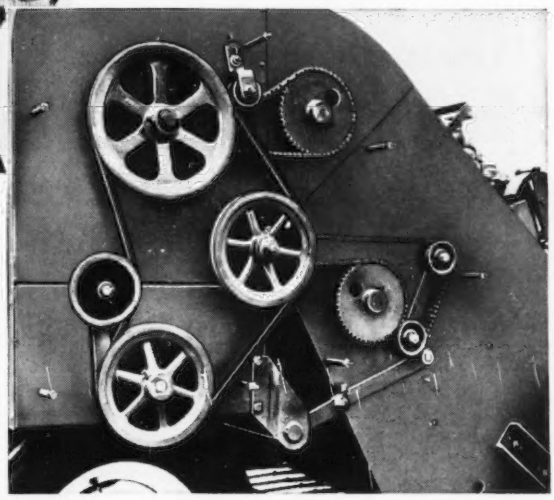
The fifth Dayton V-Belt is a C-Section agricultural belt which drives the Pick Up and Feeder sheave. On the Pick Up and Feeder drive the belt is held under constant tension and is *designed to slip* when feeder or pick-up is overloaded. Clutching action here is accomplished by means of a back side idler.

In each instance, drives require double duty, front and back, from the V-Belts delivering the power. To gain this greater power and insure long, economical operation, the New Holland Machine Co. selected Dayton V-Belts to do the job. Performance by the Super "77" has proved the wisdom of that selection over and over again.

Main Drive Assures Maximum Power

Four Dayton B-Section V-Belts transmit the power developed by this new four cylinder VF-4, 24 horsepower, air-cooled engine, to the Full-Floating Pick Up Suspension. Operating over a serpentine-type drive such as this requires great tenacity and gripping power, which these rugged, perfectly matched Dayton V-Belts supply with ease. This is a V-Flat drive with the back side of the belts driving directly on the outside diameter of the baler flywheel. Clutching action is achieved by means of a movable idler pulley.

Dayton V-Belts' unique construction absorbs the shocks of suddenly applied power through seating action in the pulley grooves. This assures smoother starting and running and eliminates vibration. Unaffected by dust or moisture-laden atmosphere, Dayton V-Belts are the perfect answer to main drive applications.



Speed baling pays big dividends

Baling at the rate of 8 bales per minute with the new Super "77" has many dollar and cents advantages. Owners can make the most of ideal baling weather, get the job done faster and pay for the new baler out of proceeds from custom baling on neighboring farms. Because the stronger, harder-gripping Dayton V-Belts on the main drive transmit every ounce of power developed, maximum baling capacity is obtained at minimum cost. Too, because the Dayton V-Belt on the Feeder Drive does permit slippage, more expensive metal parts are saved from costly overload wear and breakage. Also, Dayton V-Belts' longer service life means lower, less frequent replacement cost throughout the life of the baler.

You, too, can do as New Holland Machine Co. has done —place your V-Power requirements with Dayton Rubber Co. for complete satisfaction on any V-power drive. Just write to Dayton Rubber Co., Agricultural O.E.M. Division, Dept. 404, 1500 S. Western Ave., Chicago, Illinois.

Feeder and Pickup Drive

Lifeline of the Full-Floating Pick-Up that gives New Holland's Super "77" its sensational performance record is this sturdy C-Section Dayton V-Belt. Held under constant tension, this powerful Dayton Agricultural V-Belt is so designed that it will permit slippage in the event of overload on the feeder or pick up, thus saving undue wear on costly metal moving parts. Clutching action is accomplished by means of engaging or disengaging a back side idler. The inherent characteristics of this Dayton V-Belt make it ideally suited to give peak performance on this tough farm drive.

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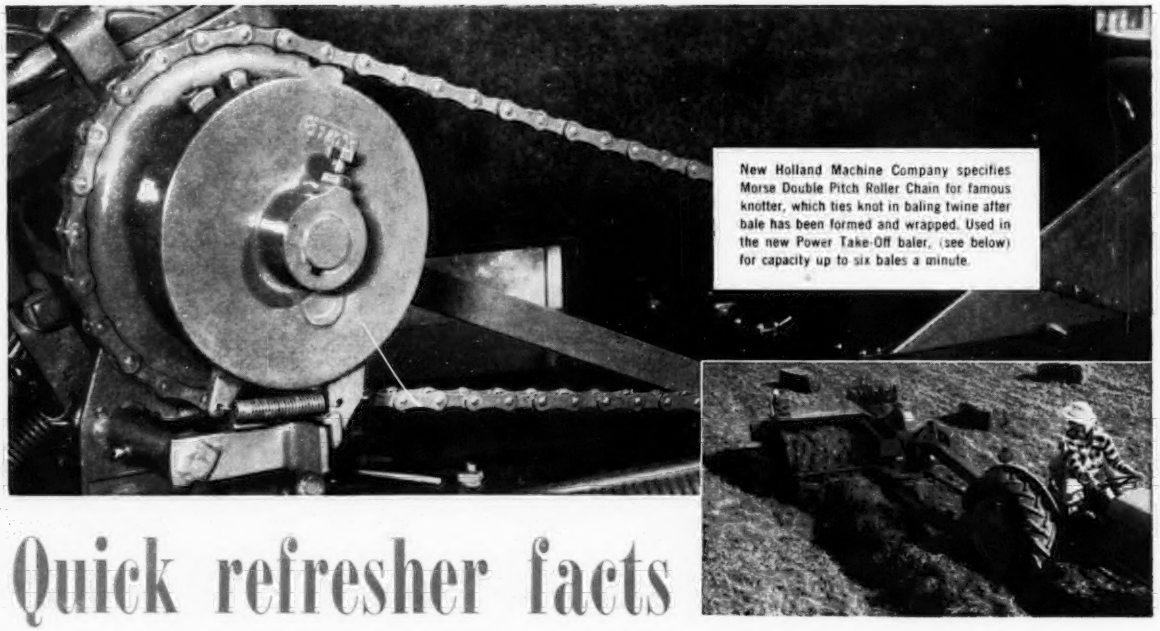
Dayton Rubber

Since 1905

First in Agricultural V-Belts

Agricultural Sales Engineers in Chicago, Moline, New York, San Francisco, Cincinnati and St. Louis



New Holland Machine Company specifies Morse Double Pitch Roller Chain for famous knotter, which ties knot in baling twine after bale has been formed and wrapped. Used in the new Power Take-Off baler, (see below) for capacity up to six bales a minute.

Quick refresher facts

ON MORSE DOUBLE PITCH CHAINS

You gain parts economy and increased customer satisfaction when you equip your farm machinery with Morse Double Pitch Chains.

DESIGN, ECONOMY FACTORS

You cut problems raised by gradual pitch elongation to a new low with these tough, precision-built, steel chains. Your customers will welcome freedom from maintenance cost, time loss and annoyance.

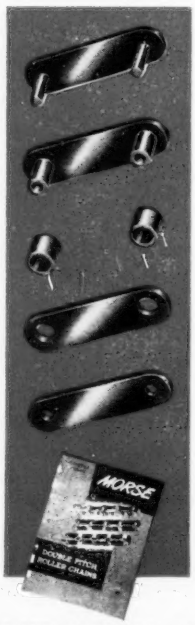
Morse Double Pitch Chains come in two series, *Power Transmission* and *Conveyor*. Both series are adaptable to a maximum range of applications, can be used with standard and special attachments.

Double Pitch Chains are ideally suited for applications where rotative speeds are low and the power to be transmitted is within the capacity of a single strand chain. In comparison with standard roller chains, they weigh less, cost less; with proper care, they provide the same long life. Parallel strands wear evenly—a particular advantage for conveying work.

STAMINA FACTORS

Morse Double Pitch Chains will wear longer, give more satisfactory, all-round performance, help reduce downtime. Here are a few reasons:

1. PINS. Heat-treated special high-nickel, fine grain alloy steel pins have extremely hard case for wear resistance, tough inner core for high strength.



2. PIN LINKS. In Morse Double Pitch Chains, heavy press fit holds pins immobile in pin link plates. Accuracy of assembly and close fit tolerance of pin and plate components assure proper clearances between pins and bushings.

3. BUSHINGS. Morse bushings are case hardened and heat treated for maximum wear. Smooth inner bearing surfaces and true roundness help eliminate pin scoring, increase joint life, reduce elongation.

4. ROLLERS. Rollers, processed from special alloy steel, are shot-peened for maximum wear and resistance to shock.

5. LINK PLATES. Morse link plates are specially treated to obtain maximum structural strength and maximum endurance qualities necessary in highly stressed tension parts.

If you'd like sound, effective engineering help on drive design, attachment selection, or any related mechanical-power-transmission problem that's bothering you, let us put you in touch with one of our skilled Morse Men. Or, write for Catalog C52-52. MORSE CHAIN COMPANY, 7601 Central Avenue, Detroit 10, Michigan.

FOR 24 REASONS, MASTERS OF MECHANICAL POWER TRANSMISSION SINCE 1893

HYDRAULICS FOR MOBILE EQUIPMENT

VOL. 2

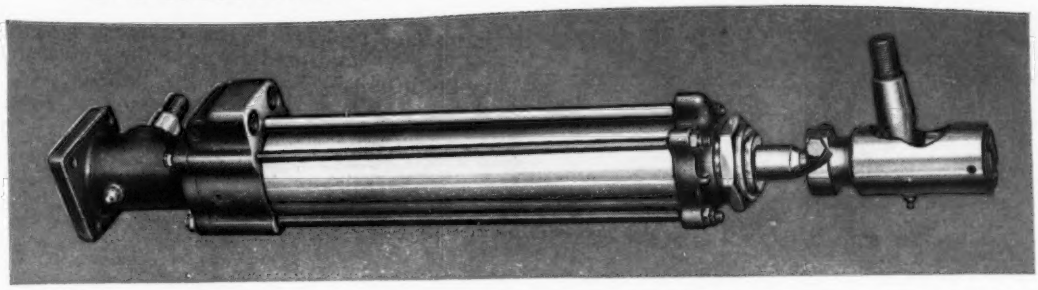
Mobile Equipment News

VICKERS INCORPORATED, DETROIT, MICHIGAN

IMPROVES PERFORMANCE • CUTS COSTS

NO. 5

New! VICKERS® HYDRAULIC POWER STEERING BOOSTER...SERIES S23



LATEST DEVELOPMENT in POWER STEERING for TRUCKS, BUSES, MATERIALS HANDLING VEHICLES, ROAD CONSTRUCTION and MINING MACHINERY

More compact . . . improved in operating characteristics . . . this new Vickers Steering Booster, Series S23 is an important new development in power steering for many vehicles. Application is much easier because it requires less space . . . and ultimate costs are substantially lower. Series S23 thus opens the way to fingertip ease of steering for a wide range of additional vehicles.

Like the preceding models, Series S23 has hydraulic lock against road shock. Bumps, chuckholes, blown front tires, obstructions, etc., cannot spin the steering wheel or jerk it out of control. This is a safety factor of great importance.

In the interest of better operation and as a logical design improvement, the integral relief valve has been omitted from Series S23 and combined with a volume control valve. Vickers VT16 and VT17 pumps have integral volume control and relief valves. Where larger pumps are required, a separate combination valve is used (see Series FM2 below).

ASK FOR NEW BULLETIN M5106

MORE VERSATILE INSTALLATION

In Series S23 Boosters, the servo ball stud housing is symmetrical, and can be assembled in any one of four positions. This and the compactness of the Booster makes application easier . . . increases the number of applications which can be made without major engineering changes. Series S23 Booster may be mounted interchangeably with Series S6-270 Booster, however a relief valve must be provided either by use of VT16 or VT17 pumps or Series FM2 volume control and overload relief valve.

REQUIRES LESS SPACE

The new booster has been reduced in size by the redesign of the servo control valve. The tube connecting the servo valve to the rod end has been relocated and is now on the same side as the fitting connection. As a result of these changes, Series S23 requires less space . . . works in closer quarters.

6795

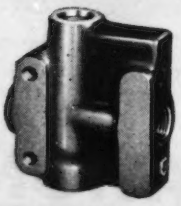
VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1516 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO AREA (Brookfield) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • NEW YORK AREA (Summit, N. J.) • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • ROCHESTER ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • TULSA WASHINGTON • WORCESTER

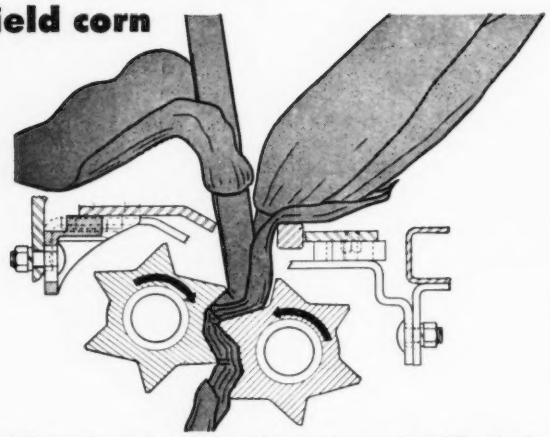
VICKERS® VOLUME CONTROL and OVERLOAD RELIEF VALVE



Five sizes of Series FM2 Valves were developed primarily for hydraulic power steering on trucks, buses and materials handling equipment where the pump does not include a volume control valve. The FM2 improves steering booster performance by providing a relatively constant volume of oil regardless of engine speed variations. An integral relief valve is included.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

IH Engineers develop new principle for picking sweet corn and snapping field corn



As stalks are drawn through the picker unit by star-shaped fluted rolls, ears are snapped off by stripper plates. Ears do not contact the rolls.

Butt-action snapping of ears from stalks is the new principle introduced to corn harvesting in a new series of McCormick® corn snappers and a sweet corn picker. In these new machines, star-type rolls with straight flutes draw the stalks through stripper plates above the rolls. As the stalks are drawn down, the plates snap the ears from the stalks. This snapping action takes place against the butts of the ears. Consequently, there is little damage to milk-filled sweet corn ears. There is no husking or shelling of mature field corn.

Both roll and stripper plate spacings are adjustable, on the go, by controls within convenient reach of the tractor driver.

Sweet corn picker and corn snapper are similar in design except for the ear conveying system and roll speed. Mass production of the corn snappers makes it possible to supply the limited sweet corn picker market at a considerable saving to the grower.

The new McCormick two-row sweet corn picker (illustrated) mounts on the Farmall® Super M or M-TA. The two-row corn snapper mounts on Farmalls Super M-TA, Super H or earlier models. A one-row mounted snapper is available for Farmall C and Super C tractors.

IH engineering teamwork produced the new McCormick sweet corn picker and field corn snappers. IH research, engineering and manufacturing men are constantly pooling time and talent to provide equipment that makes farm work easier and the farmer's time more productive.

INTERNATIONAL HARVESTER

International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler Tractors and Power Units . . . Refrigerators and Freezers—General Office, Chicago 1, Ill.

"My steel building is a good investment... a real improvement to my farm"

says Clarence E. Bratsch
Danube, Minnesota

Mr. Bratsch and two of his sons in their clear-span steel building. Mr. Bratsch is in the center, and his sons on the tractors are Ervin, left and Alver, right.

● When asked why he preferred his steel building to any other type, Mr. Bratsch replied from personal experience, "In the summer of 1952 I put up a wooden machine shed, 40 by 70 feet. My three sons, two carpenters and I put up the shed in three weeks. Last summer, I bought an all-steel machine shed, 36 by 80 feet. A six-man crew erected the steel building in just three days. And although the *steel building is larger, the actual cost of the finished building was less.*"

Mr. Bratsch owns more than $60,000 worth of farm machinery, which he stores in his steel building. "My steel building is worth more, too, because it's fireproof—I don't have to worry about a serious fire that could damage a lot of high-priced farm machinery and my other buildings."

Being a very practical man, Mr. Bratsch considers his steel building an investment in the future of his farm. In his own words, "Two of my sons and I farm 680 acres 7 miles south of Danube. We haven't any time to spend in repairing or replacing buildings, and it is hard to hire work done. To make farming pay off today, you have to be sure that your time is spent right and that *every dollar invested in equipment will bring a good return* in one way or another. My steel building is a good investment because it saves in maintenance, it looks nice, and is a real improvement to my farm."

You, too, will get the most for your money when you invest in a factory-made steel building, manufactured with long-lasting U·S·S Galvanized Steel Sheets for roofs and walls and a U·S·S Structural Steel framework. U·S·S Galvanized Steel Sheets contain a guaranteed 1¼ ounce coating of zinc per sq. ft. in accordance with ASTM Specifications.

USS

4-455

UNITED STATES STEEL

United States Steel Corporation produces high-quality U·S·S Galvanized Sheets and Structural Steel which our customers manufacture into durable farm buildings. Your requests for information will be forwarded to the manufacturers of these buildings, and you will hear directly from them.

SEND THIS COUPON FOR FURTHER INFORMATION

Agricultural Extension Section,
United States Steel Corporation
Room 4264, 525 William Penn Place
Pittsburgh 30, Pa.

I am interested in steel buildings for the following:

☐ machinery storage ☐ cattle shelters
☐ grain storage ☐ dairy barns
☐ hay storage ☐ poultry houses
☐ other.....

Approximate size or capacity .....
Send information to:

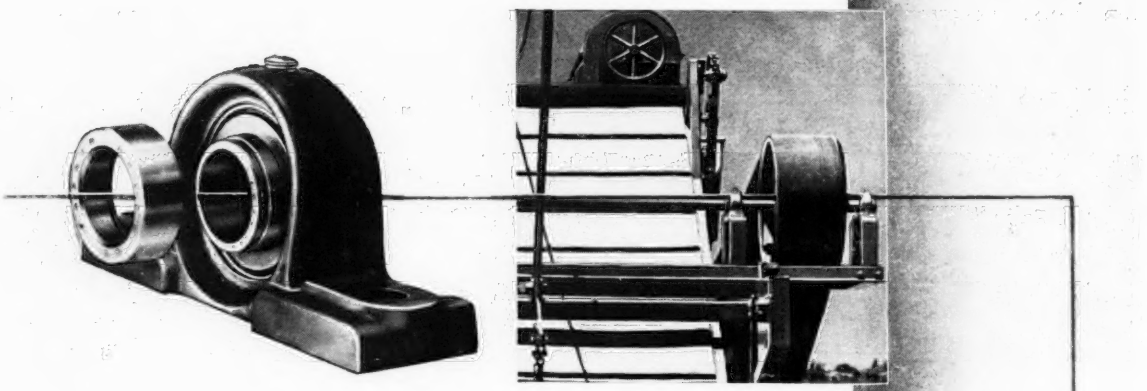
Name.....

Address..... **Town**.....

County..... **State**.....

☐ Please have a representative call on me with further information.

The Engagement Ring makes it positive



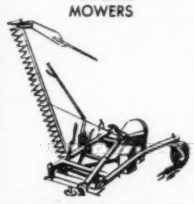
When important shafts on farm machinery and Fafnir Wide Inner Ring Ball Bearings become engaged . . . there's never any question about shaft slippage. The engagement ring, known as the Fafnir originated Self-Locking Collar, makes the union positive beyond a doubt.

In the design of the Self-Locking Collar, you'll find the reason for this positive action. The collar is machined as a mating eccentric cam to the wide inner ring of the bearing . . . and it is counterbored too. A quarter turn of the collar on the inner ring assures positive locking action between bearing and shaft. No set screw, lock nuts or adapters are needed. No adjustments of any kind are necessary and the bearing cannot be cramped or overloaded in mounting.

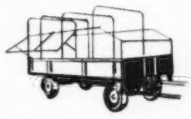
For straight shaft mounting, the Fafnir Wide Inner Ring Ball Bearing with Self-Locking Collar continues to rate "tops" as a feature of power transmission units. Its positive-engagement, *plus* simplicity-of-mounting, *plus* efficient seals are features that lead to savings in design, assembly and maintenance. Are you taking advantage of them? The Fafnir Bearing Company, New Britain, Conn.

For farm implements...

14 makes MOWERS

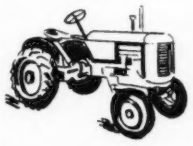


10 makes WAGON UNLOADERS

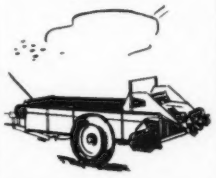


17 makes FORAGE HARVESTERS

8 makes TRACTORS

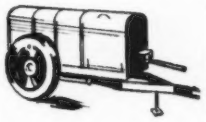


14 makes SPREADERS



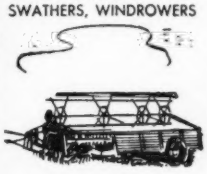
24 makes GRINDERS, MILLS

10 makes SPRAYERS

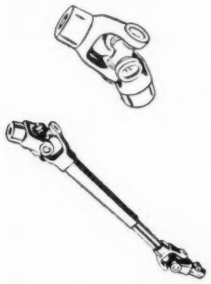


more BLOOD BROTHERS Universal Joints are used

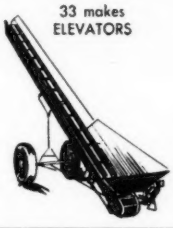
8 makes SWATHERS, WINDROWERS



11 makes POST HOLE DIGGERS



33 makes ELEVATORS

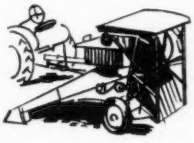


15 makes COMBINES

13 makes CORN PICKERS

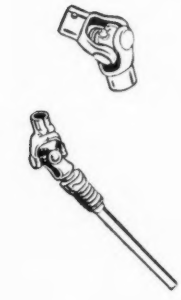
17 makes HAY RAKES

14 makes HAY BALERS



33 makes STALK, BRUSH CUTTERS, SHREDDERS

than all other makes combined!



On every kind of application — from hand-operated controls to heavy-duty P.T.O. drives — Blood Brothers Universal Joints have proved their unsurpassed suitability for farm implement use.

They are dependable — as proved by an outstanding record in the field. They are competitively priced. And Blood Brothers engineers offer a wealth of experience plus willing cooperation in helping solve your application problems.

No wonder Blood Brothers Universal Joints and Drive Line Assemblies are *first choice — by far* — with farm implement engineers!

WRITE FOR SPECIFIC DATA.

BLOOD BROTHERS machine division
Rockwell Spring and Axle Company
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

How we opened the door to lower costs for Ford

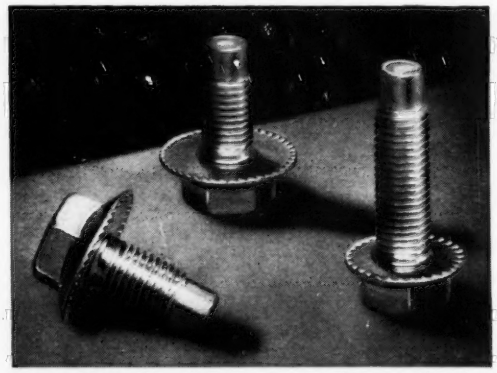
Two hinges on every Ford door. Six screws and 12 washers for each hinge.

Did this present an opportunity for cost reduction? An RB&W "fastener engineer" thought so. And after careful analysis and time studies Ford engineers agreed.

The solution: RB&W Hex SPIN-LOCK screws to fasten the hinge to the door, eliminating the need for washers. And special wide-flange Hex SPIN-LOCK screws for attaching the hinge to the frame, doing away with more washers. The wide flange is necessary to cover an elongated hole in which the hinge moves to permit accurate alignment.

Result — parts requirements are cut by two thirds, assembly is simplified, purchasing and inventory costs are lowered. And RB&W SPIN-LOCK screws hold those door hinges tight for good.

We will be glad to send an RB&W man around to check up on your fastening operations. Every problem is different, of course, but RB&W has a fastener for just about every job. If you need a "special", as Ford did, we'll design and make it for you. Write RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY, Port Chester, New York.



FASTER ASSEMBLY, reduced costs were the pay-off, using RB&W designed wide-flange SPIN-LOCK screws (left) for door hinge. Other SPIN-LOCKS (right) hold hinge on door. SPIN-LOCK screws *can't loosen* because ratchet-like teeth lock into surface and hold tight.

3.10

RB&W

109 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

Plants at: **PORT CHESTER, N.Y.; CORAOPOLIS, PA.; ROCK FALLS, ILL.; LOS ANGELES, CALIF.** ***Additional sales offices at:*** **ARDMORE (PHILA.), PA.; PITTSBURGH; DETROIT; CHICAGO; DALLAS; SAN FRANCISCO.** ***Sales agents at:*** **PORTLAND, SEATTLE.** ***Distributors from coast to coast.***

LOW-COST MOTOR GRADER

handles unlimited jobs on a limited budget

How often have you seen earth-moving jobs that were too big to be handled efficiently with ordinary farm implements, yet did not warrant the cost of a large motor grader? Jobs like these are made to order for the Allis-Chalmers Model D Motor Grader.

Here is a real earth-moving machine — a *natural* for such jobs as building terraces, waterways, diversion ditches, shallow stock ponds and farm roads. The tandem drive Model D has all the essential design and performance advantages of large motor graders, yet it costs only ⅓ as much.

But its advantages go far beyond the cost sheet. For example, its compact design and short turning radius enable it to work close to fences, to travel easily through farm lanes and across farm bridges. What's more, any mechanic can service its 50-hp. gasoline engine. Parts are carried by all Allis-Chalmers tractor dealers.

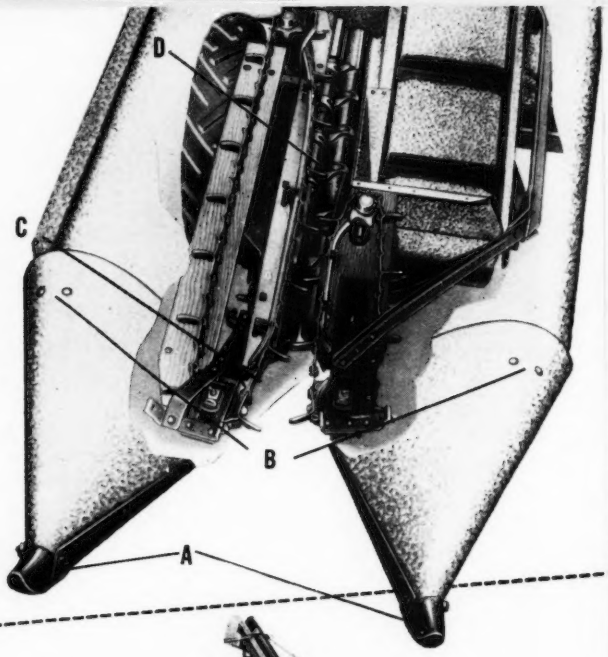
Let your Allis-Chalmers industrial tractor dealer show you the Model D in action. See for yourself how nicely it fits the job . . . how easily it fits the budget.

Brake hp., 50
Weight, 8,800 lb.
Speeds, 4 forward to 25.6 mph.
Reverse, 3.3 mph.

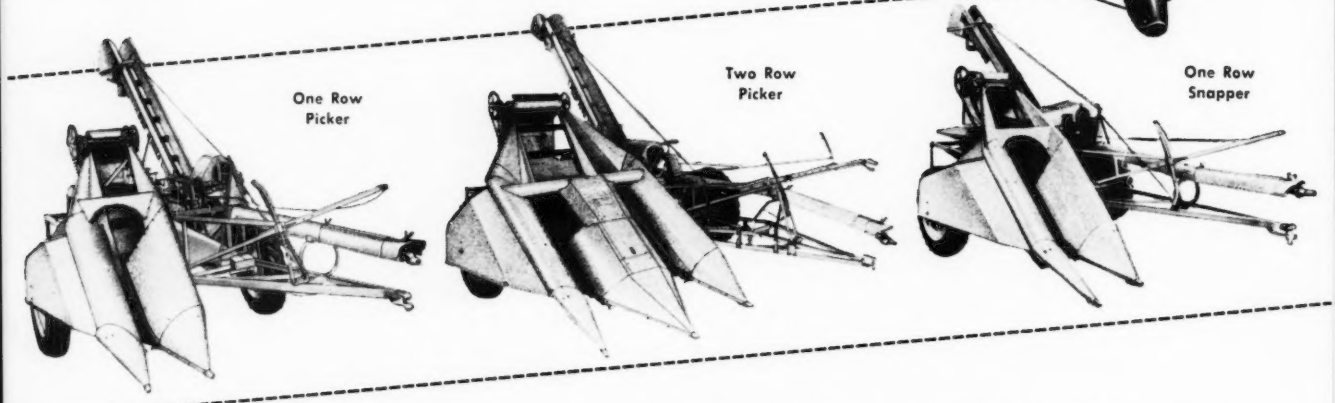
OPTIONAL EQUIPMENT
Scarifier
Leaning Front Wheels
Power Circle Turn
Rear-Mounted, ⅝ cu. yd. Hydraulic Loader

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

NEW IDEA "KNOW-HOW" makes corn picking champions

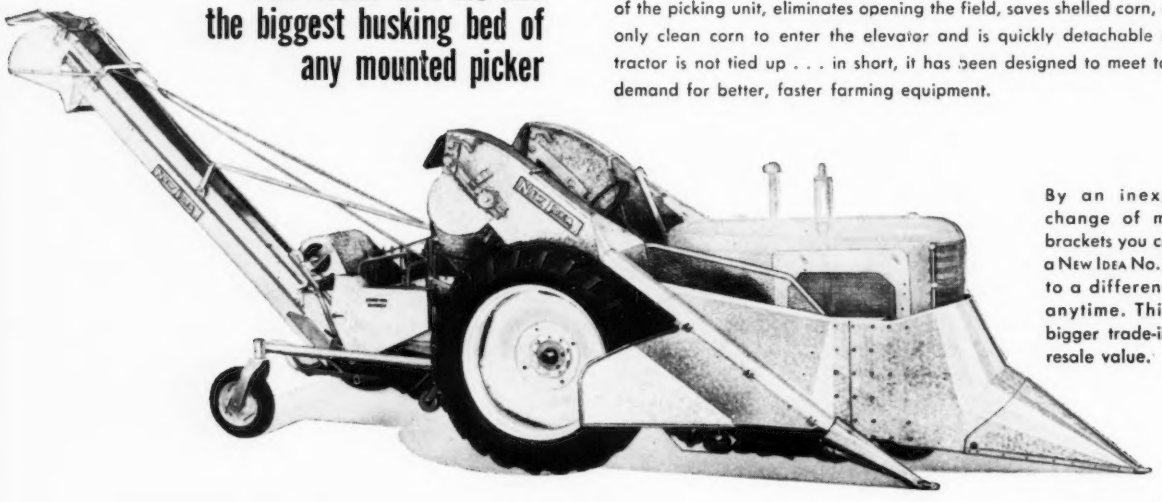


Here are the famous "Floating Points" which have helped NEW IDEA pickers win more contests than any other make. Good picking begins right here at these floating points and low reaching gathering chains. At "A" note the contour-hugging floating points hinged "B" above the low-reach gathering chains "C" which handle down and tangled stalks with ease. Specially designed snapping rolls "D" complete this outstanding picker combination.



This **NEW No. 20** has the biggest husking bed of any mounted picker

There's no waste, no corn left in the field, when you use the NEW IDEA No. 20 Mounted Picker. It makes sharp turns, gives unobstructed view of the picking unit, eliminates opening the field, saves shelled corn, allows only clean corn to enter the elevator and is quickly detachable so the tractor is not tied up . . . in short, it has been designed to meet today's demand for better, faster farming equipment.



By an inexpensive change of mounting brackets you can switch a NEW IDEA No. 20 Picker to a different tractor anytime. This means bigger trade-in, higher resale value.

NEW IDEAS for better farming since 1899

NEW IDEA
FARM EQUIPMENT COMPANY
Division AVCO Distributing Corporation
COLDWATER, OHIO, U. S. A.

NEW IDEA FARM EQUIPMENT

CHECK these important differences in augers for farm machines

- **ONE-PIECE HELICOID FLIGHTING** has greater smoothness and strength. Link-Belt also builds many different shapes in various metals to meet your specific needs—cut flight, short pitch, ribbon flight, tapering, double flight to name a few.
- **UNIFORM PITCH** — Specialized modern machinery assures accurate forming, producing uniformity in flighting curvature.
- **ONLY SPECIALLY SELECTED STEELS** are used to meet Link-Belt's rigid specifications — assuring smooth flight surfaces.
- **STRAIGHTNESS** is checked before shipping and extra care is taken in handling and loading.

Complete auger for this harvester-thresher is furnished by Link-Belt. Opposed flights move cut grain to center, deliver it to pick-up conveyor.

LINK-BELT gives you sound engineering plus accuracy of manufacture for top performance

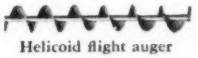
WHEN you make a Link-Belt auger part of your farm machine, you can be sure of efficient operation plus long-life, low-maintenance service. Link-Belt builds augers for every purpose—gathering cut grain back of the sickle bar, conveying, elevating, spreading, feeding, mixing or digging.

Each can be engineered for your specific requirements . . . each will provide long-lasting efficiency, thanks to Link-Belt's unequalled accuracy of manufacture. Let your nearby Link-Belt sales representative point out the many important differences in augers to you. And be sure he gives you a copy of Book 2289, covering Link-Belt's regular line of conveyor screws and components.

Typical examples of Link-Belt Augers

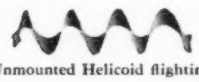
Sectional-flight

Helicoid flight with end, plain beater



Helicoid flight auger

Opposed flights with center saw-tooth beater



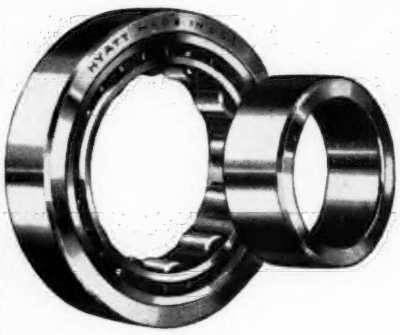
Unmounted Helicoid flighting

LINK-BELT

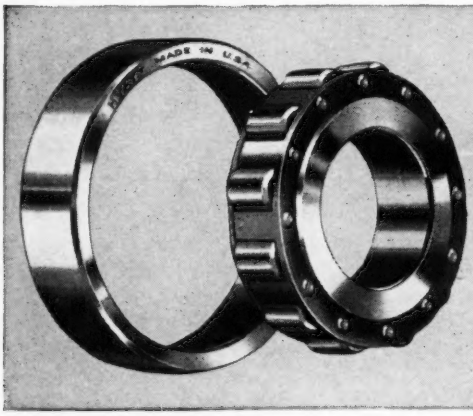
FARM MACHINE AUGERS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N. S. W.; South Africa, Springs. Representatives Throughout the World. 13,384

3 ways to handle your RADIAL LOAD PROBLEM

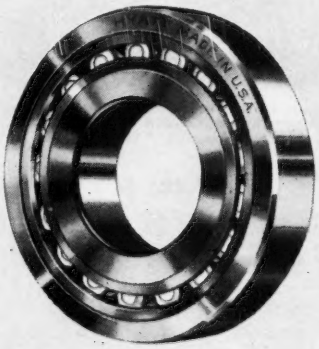


1 If your design requires a large shaft diameter to produce greater rigidity without disturbing boundary dimensions, a separable inner race type Hyatt Hy-Load bearing can be used with the inner race omitted. Rollers operate directly on a suitable hardened and ground shaft.



2 When the housing bore must be kept to a minimum, a Hyatt Hy-Load bearing with a separable outer race can be used—with the outer race omitted. The rollers then operate directly in a housing bore of suitable hardness and finish.

If your design applications involve radial loads, the best way to handle the job is with Hyatts—for Hyatt offers industry's most complete line of straight radial roller bearings! Hyatt Hy-Loads, for example, are made in three diameter series and two basic widths, to standard dimensions. There are ten major types—for the heaviest radial loads, and light or intermittent thrust loads. Four have separable inner races, two have separable outer races and four are non-separable, thus permitting wide flexibility in design and assembly procedures. Write for our general catalog No. 150—it will put the solution to any roller bearing problem at your fingertips. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



3 For designs requiring a bearing installed as a unit, there is the non-separable type of Hyatt Hy-Load. Whether you select a separable or non-separable type of Hyatt Hy-Load, they are available in a wide range of sizes.

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

AGRICULTURAL ENGINEERING

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Machine Processes Corncobs

Darwin C. Bichel and Roger Yoerger
Assoc. Member ASAE Assoc. Member ASAE

Agricultural Engineers Develop Economical Method of Reducing and Handling Cobs

CORN is the most important crop grown in the United States. Annual yields during the past five-year period have averaged well over 3 billion bushels. One of the by-products of this production is a quantity of corncobs amounting to more than 21 million tons each year. A few years ago the majority of the corncobs were used as fuel for heating and cooking in corn belt homes; however, since electricity and other fuels were made practical for rural use, the widespread utilization of corncobs has become a big problem.

Corncobs have found many uses in industry, but only a small percentage of the total production is utilized in this way. The greatest amount of cobs used in industry, about 2 percent of the annual yield, is in the manufacture of furfural. Other industrial uses include soft-grit blasting of metals, absorbents and driers, fur cleaning, abrasives for hand soap and many others.

Corncobs are also used in many ways on the farm. These uses include garden mulching, insulation, animal bedding, poultry litter and animal feed.

One of the problems encountered in the utilization of corncobs is that of mechanical processing. Before they can be put to use, the cobs must be reduced to a certain size. This size ranges from fine flour to particles up to an inch long, depending on how they are to be used. On the farm, feed mills are usually used for the coarser reductions. However, most of the hammer mills and burr grinders used for feed grinding do not handle corncobs satisfactorily. Hammer mills have a high power requirement, a short life and do not deliver a product of uniform size. The dust produced in grinding cobs with this type of mill is especially serious when the material is used for poultry litter. Burr mills deliver a product of more uniform size but they have a low capacity and a high power requirement.

The ideal method for processing corncobs would be to reduce them to a coarse size as they come from the corn sheller on the farm or at the elevator. This would reduce the handling of the cobs and also increase the specific weight, so that more cobs could be transported in a given space.

In an attempt to meet the need for a farm machine that would handle corncobs satisfactorily, a corncob processing machine was designed, constructed and tested at the agricultural engineering department of Iowa State College.

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The authors—DARWIN C. BICHEL and ROGER YOERGER—are, respectively, formerly instructor in agricultural engineering, Iowa State College, now product development engineer, Deere and Co., and assistant professor of agricultural engineering, Iowa Agricultural Experiment Station.

Approach to the Design of the Corncob Processing Machine

The primary purpose of the machine was to reduce the cobs to such a size that the product could be used on the farm as poultry litter, animal bedding and mulch. An investigation of the sizes of particles best suited for these purposes showed that particles which pass a 1-mesh screen and are retained on a 4-mesh screen make the best poultry litter. Somewhat coarser particles are used for animal litter, and for mulching the particles should be quite large to prevent their being carried by the wind. Particles of these sizes can also be used in the manufacture of furfural. For those uses of ground cobs which require finer particles, this machine could be used for the first reduction.

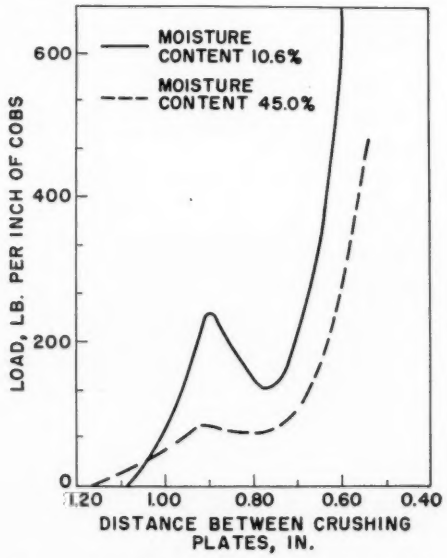


Fig. 1 Load-deflection curve for wet and dry cobs (average for all tests)

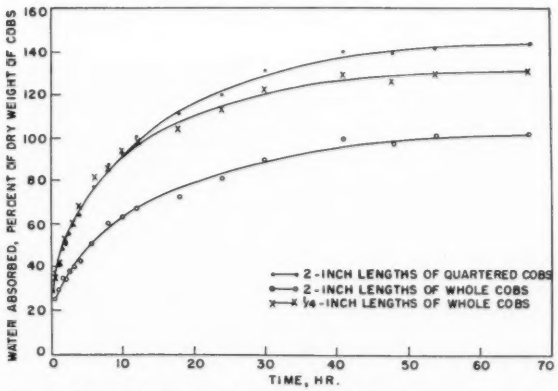


Fig. 2 Water-absorbtion characteristics of three types of corncob particles when submerged in water

The capacity of the machine was to be such that it would handle the cobs from a 1000 bu-per hr sheller, or about 7 tons of cobs per hour. The power requirement was not to exceed 30 hp at this capacity so that it could be powered by a farm tractor. The machine was to be portable to facilitate its use as a custom machine to supplement the custom corn sheller.

A preliminary study was made of some of the physical properties of corncobs to determine their crushing characteristics and, since one of the main uses on the farm are for moisture absorption, the moisture absorption and holding characteristics of different types of particles.

Structurally the cob may be divided into four parts: *(a)* fine chaff, 4 percent; *(b)* coarse chaff, 34 percent; *(c)* woody ring, 60 percent, and *(d)* pith, 2 percent. The main structural portion of the cob is the woody ring which may be considered a thick-walled cylinder. When the cob is compressed laterally, failure begins in tension at the inner surfaces of the cylinder in the plane of the force and at the outer surfaces in the orthogonal plane. The result is a quartering of the corncob along its length.

Investigations of the forces required to quarter individual corncobs were made by compressing the cobs between two flat plates. The loads varied from 153 to 316 lb per in of cob length for cobs with 10.6 percent moisture and from 37 to 111 lb for cobs with 45.0 percent moisture. The load-deflection curves followed the same pattern for each cob tested. The average curves are shown in Fig. 1. The cobs supported a certain load until they started to fracture. Then the load decreased as the crushing plates were brought closer together. After the cobs had split completely, the load increased rapidly for a small amount of deflection. It was noted that most of the cobs were completely split by the time the crushing plates were brought within 0.75 in of each other. Further compression did not break the cob any more but tended to bond the quarters together again. It was also noted when compressing the cobs that the fracture occurring perpendicular to the plane of the forces did not continue completely through the center of the cob. As a result the quarters would remain fastened together in pairs.

Investigations of the water absorption rate and capacity of different types of cob particles were made by submerging the particles in water and noting their change in weight at certain time intervals. The particles tested were 2-in lengths of whole cobs, ¼-in lengths of whole cobs and 2-in lengths of quartered cobs.

The resulting moisture absorption curves are shown in Fig. 2. The quartered cobs absorbed more water than did either length of the whole cob particles and the rate of absorption was greater after a certain time interval. This was possibly due to the greater freedom of expansion by the quartered cobs as they absorbed water. The woody ring of the whole cobs probably restricted their expansion and therefore reduced the absorption rate and capacity.

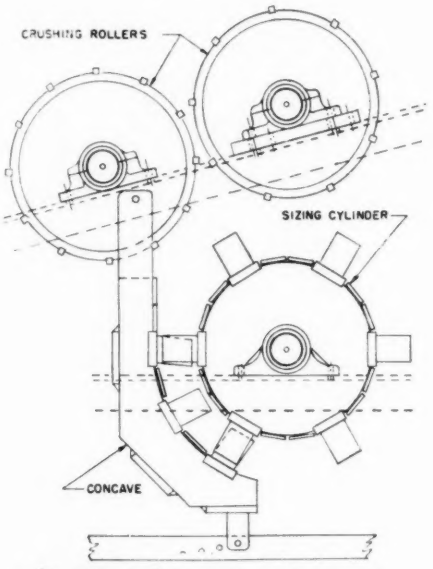


Fig. 3 Sketch of the crushing and sizing unit

Design of the Machine

The crushing characteristics of corncobs indicated that rollers would break the cobs into quarters and could possibly be used as the crushing mechanism in the machine. Several different rollers were tested for this purpose and it was found that corncobs would not feed through smooth rollers that were set close together. This was true for rollers of 16 in in diameter. It was also found that rollers alone did not break the cobs into very small particles. The quarters stuck together and were not broken into short lengths. Plates with a waffle-iron pattern were made up and the cobs were crushed between them to determine if rollers with a similar pattern would both quarter the cobs and break them into short lengths. The cobs stuck in the depressions in the plates, so it was believed that this type of roller would not operate satisfactorily.

The crushing unit decided upon reduces the cobs in two operations. Rollers are first used to quarter the cobs. These

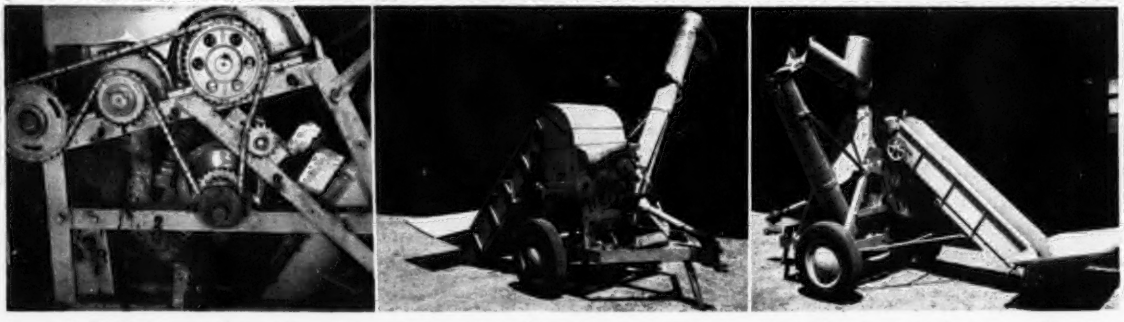
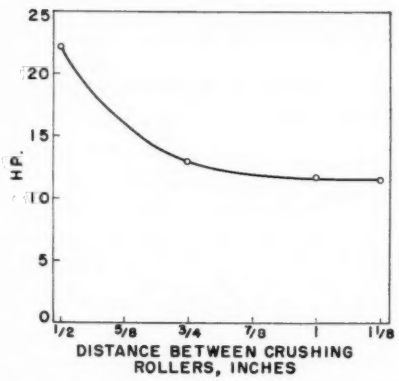


Fig. 4 *(Left)* Front view of corncob crushing machine with shields and housing removed • Fig. 5 *(Center)* Right front view of machine with auger extended • Fig. 6 *(Right)* Left rear view of machine with the top section of auger folded back



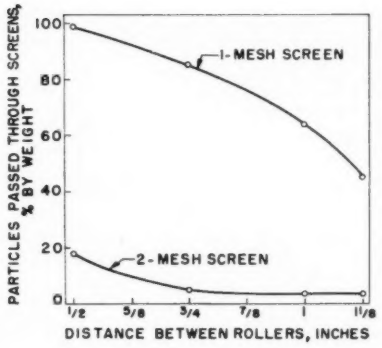


Fig. 7 *(Left)* Effect of crushing roller spacing on power requirement at 8 tons per hour • Fig. 8 *(Right)* Effect of crusher roller spacing on amount of particles passing 1-mesh and 2-mesh screens

rollers were made of 10-in extra strong pipe. Three-eighths-inch square bars were set into longitudinally milled slots ⅛ in deep around the periphery of the pipe, so ¼-in bars protruded above the surface of the roll. This made the rollers more aggressive and resulted in better feeding of the cobs between them. One of these rollers is driven at 283 rpm and the other at 425 rpm. The resulting opposing forces on the cobs helps to pull the quarters of the cobs apart. The distance between the rollers is adjustable.

The second operation in the crushing unit is that of sizing. The quartered cobs drop into a concave and cylinder arrangement. The sizing cylinder is 14⅜ in in diameter and contains six rows of teeth. These pull the quartered cobs through three rows of concave teeth breaking the quarters into short pieces and also pulling apart the quarters which are still stuck together. The distance between the concave and cylinder is adjustable. The crushing mechanism is driven by the power take-off of a tractor. The power take-off shaft is connected to the sizing cylinder shaft and the rollers are driven by a roller chain from a sprocket on this shaft. The arrangement of the unit is shown in Figs. 3 and 4.

A chain-flight elevator is used to feed the cobs into a hopper over the rollers and an auger elevator is used to remove and elevate the crushed cobs from the machine. Both these elevators are mounted on the main frame of the machine. The input elevator is adjustable to different heights and can be raised off the ground during transportation. The auger elevator is made in two sections. The top section can be folded back over the machine for transporting. The machine is mounted on two wheels to make a very portable self-contained unit. Two views of the complete machine are shown in Figs. 5 and 6.

Performance of the Corncob Processing Machine

After a few preliminary trials, formal testing was started to determine the capacity, power requirement and size of the product delivered by the machine at various roller spacings and concave settings. The power requirement of the machine was determined by the use of a hydraulic-torque indicator in the power take-off shaft. The capacity of the machine was determined in each test by weighing the amount of cobs delivered by the machine in a certain time interval while it was being choke fed. The sizes of cob particles delivered by the machine in each test were determined by screening the small samples of cobs obtained during each test. The screen sizes used were 1-mesh, 2-mesh, 3-mesh and 4-mesh. The cobs used in all the tests contained an average of 12.8 percent moisture.

The maximum capacity of the machine varied from 11.44 to 7.29 tons per hour, depending on the roller spacing and concave setting. The greatest capacity was obtained at the ¾-in spacing of the rollers and a concave setting of 70 percent overlap of the concave and sizing cylinder teeth.

The power required by the machine to crush 8 tons of cobs per hour was plotted against crushing roller spacing to determine the effect of the distance between the rollers on the power requirement. This chart is shown in Fig. 7. The power requirement increased rapidly when the rollers were set less than ¾-in apart. This agreed with the results of the study made of the crushing characteristics of cobs. It was found that the concave settings had no great effect on the power required by the machine.

The adjustment of the crushing rollers affected the size of particles delivered by the machine to a much greater extent than did the concave settings. Fig. 8 shows the effect of the crushing roller spacing on the amount of the particles passing the 1-mesh and the 2-mesh screens. At all adjustments of the machine only a very small percentage of the particles passed the 3-mesh and the 4-mesh screens. The maximum amount of particles which passed these screens were from the product delivered when the crushing rollers were ½ in apart and the concave was completely closed. At this setting 5.7 percent of the particles passed the 3-mesh screen and 3.7 percent passed the 4-mesh screen.

From the results obtained from the tests, it seemed that the ¾-in spacing between the crushing rollers in combination with the completely closed concave gave the most desirable performance in the corncob processing machine. At this adjustment, the maximum capacity of the machine was 11.12 tons per hour with a power requirement of 20.55 hp. This means that 1.85 hp-hr per ton was used to crush cobs with 12.8 percent moisture. The product delivered at this adjustment was such that 86.5 percent of it passed the 1-mesh screen and 7.2 percent passed the 2-mesh screen. Only 0.9 percent of it passed the 4-mesh screen.

The product delivered by this machine is satisfactory for poultry litter, animal bedding and mulch because of the absence of the undesirable fine material. The high capacity and low power requirement of the machine makes it an economical means of reducing cobs.

Summary

The utilization of the great amount of corncobs produced in the United States is made difficult because of the lack of an economical method of reducing and handling the cobs. To determine what kind of machine would economically reduce cobs to a size that could be used on the farm and for some industrial purposes, some physical characteristics of the cobs were investigated. The results of these investigations were applied in the design of a roller-type cob

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A Tile Drainage Field Laboratory

Jan van Schilfgaarde, R. K. Frevert,
Assoc. Member ASAE Member ASAE
and Don Kirkham

Purpose: To Find an Empirical Criterion for Selecting Depth and Spacing of Tile

THE research project discussed in this paper represents an attempt to find an empirical criterion for the appropriate selection of the depth and spacing at which tile lines should be placed in different soils. The purpose of the paper is not to present any conclusions, but rather to describe the methods and equipment used in this study and to point out some of the difficulties encountered.

Previous Work

Many investigators have suggested theoretical solutions of certain restricted flow problems in recent years. However, those that are based on the Laplace equation have dealt only with steady state conditions. Kirkham worked with land completely saturated and flooded (1, 2)*, thus dealing with a constant head. Van Deemter (3, English abstract 4) solved the problem of constant flux through a homogeneous soil. His work, written for the main part in Dutch, is as yet little known.

Van Deemter considered a semi-infinite, homogeneous, isotropic soil with tile lines or open ditches at regular spacing, and found the exact equation for the position and the shape of the water table, given a constant rate of rainfall ($N<O$) or evaporation ($N>O$) and a known amount of deep seepage ($L<O$) or artesian pressure ($L>O$). For field use, Van Deemter presented simplified formulas for the depths of the water table immediately over the tile lines and midway between them. Only these simplified equations are repeated here:

$$\pi\, c/a = ln(1+2/\gamma) + (2/\gamma)ln(1+\gamma/2)$$
$$\pi\, b/a = ln(1+2/\gamma) + (2/\gamma)ln[(1+\gamma/2)/(1+\gamma)]$$

where c = height of water table above the center of the tile midway between tiles (Fig. 1)
b = height of water table directly above the tile
a = half-spacing between tile lines
γ = dimensionless ratio $(K+N)/(L-N)$
K = hydraulic conductivity of the soil
N = constant rate of rainfall (<0) or evaporation (>0)
L = artesian pressure (>0) or rate of deep seepage (<0)
ln = natural logarithm.

The error introduced by the simplification process is less than 10 percent as long as b is less than $c/5$. These equations give the lowest possible position of the water table for the drained land for the constant rate of rainfall and deep seepage specified. They do not apply to the case of "negative" drainage, that is, subirrigation through tile lines. It should be pointed out that, strictly speaking, Van Deemter's solution is restricted to smaller tile diameters and greater rainfall rates than are normally encountered (11).

The transient state, involving the rate of drop of the water table, has, to the knowledge of the authors, not been satisfactorily solved. Many approximations are available, but most of them [such as Aronovici and Donnan's (5) and Glover's (6)] are based on the Dupuit-Forchheimer theory which is known to have serious limitations †, and the use of which may result in serious errors. A solution by Walker (7) avoids these assumptions, but his approach hinges on his equation 2 which, tacitly and incorrectly, implies a unit hydraulic gradient. However, compensating simplifications may still make Walker's solution of practical value.

One possible approach was demonstrated in a paper by Kirkham and Gaskell (8); they used successive solutions by means of a relaxation method, a small but finite time increment apart, each new solution based on the previous one. This method is infallible, but has the serious handicap that excessive amounts of labor are required. Besides, a new solution must be found for each geometric situation. The use of an electrical resistance network as outlined by Luthin (9) may reduce the amount of labor required for relaxation solutions considerably.

Present Objective

In view of the situation just described, and because the conditions assumed in the theoretical derivations may differ from those found in the field, the Iowa Agricultural Experiment Station set out to find, in the field, a relationship expressing the time rate of change of the water table as a func-

† For a discussion of the Dupuit-Forchheimer assumptions, see, for example, M. Muskat, Flow of homogeneous fluids through porous media, Ann Arbor, Mich., J. W. Edwards, 1946, pp. 359-365.

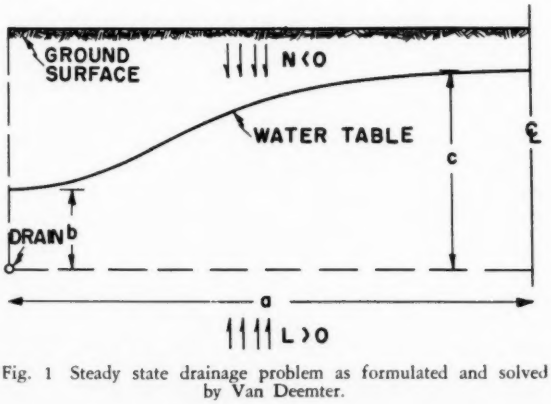

Fig. 1 Steady state drainage problem as formulated and solved by Van Deemter.

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The authors—JAN VAN SCHILFGAARDE, R. K. FREVERT, and DON KIRKHAM—are, respectively, instructor in agricultural engineering, professor of agricultural engineering and assistant director of the agricultural experiment station, and professor of agronomy (soils) and physics, Iowa State College.

* Numbers in parentheses refer to the appended bibliography.

tion of the geometry of the system and the soil properties permeability ‡ and porosity.

Description of Field Laboratory

The site chosen for this experiment is located in Woodbury County, Iowa, on bottom land along the Missouri River. It is part of a field which has about 5 ft of loess deposited over the original alluvial soil. This loess was washed down from the hills and carried down the drainage ditch that passes the field. Several times in the past, the levee along this ditch broke through and the loess settled out when the water flooded the adjoining land. Thus there now exists a field with five feet of permeable soil overlying a tight subsoil.

At this site it was planned to construct the equivalent of a sand tank, but with natural, undisturbed soil in place. A sheet metal barrier (22-gage galvanized steel) was installed to a depth of 6 ft around a rectangular area 100 x 320 ft. Three-by-eight-foot sheets were first made into 8 x 6-ft sheets by bending a 1-in strip along one side of each sheet, hooking two sheets together, caulking the joint with asphalt roofing cement and riveting the sheets together. The 8 x 6-ft sheets were lowered into a 12-in trench and nailed onto creosoted 2 x 4-in posts, and the joints caulked again with roofing compound. Bentonite was used to insure a seal between the bottom of the sheet metal and the tight soil.

Before this sheet metal barrier was installed, a barrier was made of Richkraft roofing paper. About two weeks after installation, when there was occasion to dig down along the barrier, it was found that the paper had largely disintegrated. Only where it was still exposed to the air because of incomplete backfilling of the trench, was it still in fairly good condition.

‡In this paper a distinction is made between "permeability," a property of the soil with dimensions of L^2 (as square centimeters), and "hydraulic conductivity," defined as the proportionality constant K in Darcy's Law, $v = Ki$, and having the dimensions of a rate, or LT^{-1} (as feet per day).

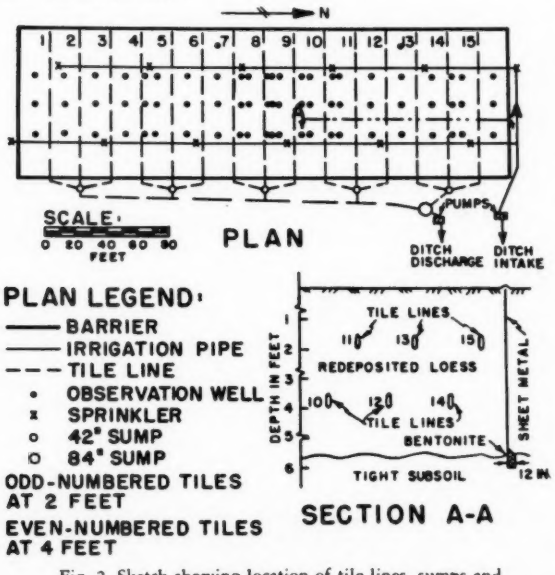

Fig. 2 Sketch showing location of tile lines, sumps and observation wells.

Inside this area (Fig. 2), fifteen tile lines were installed at 20-ft intervals, alternately at an average depth of 2 and 4 ft. The tile was laid in a hand-crumbed ditch, without special precautions. Six-inch tile at 3 percent was used to eliminate the possibility of restricted flow by inadequate capacity. From the point where the tile lines reached the barrier, sealed transite pipe or bell-and-spigot sewer tile was used to extend the lines into a series of five 42-in by 8-ft manholes placed just outside the barrier. These sealed lines allow the measurement of the total outflow out of the tile system without losses along the way.

The five manholes in turn are connected to a tile main which outlets into a large sump constructed of a 7-ft-diam corrugated metal pipe 10 ft long. This tile main is not sealed, but constructed of regular tile.

After completion of the construction, the area was leveled and seeded to a mixture of alta fescue and timothy.

The presence of the drainage ditch nearby secures a steady water supply, and an interceptor ditch just inside the levee is convenient for water disposal. A 3-in horizontal centrifugal pump has been used to pump water out of the ditch and another 3-in pump to pump water out of the sump.

Several attempts were made to find satisfactory valves to close off the tile lines, and finally it was decided to use ⅛-in steel plates with 4-in circular holes cut out (Fig. 3). By means of rubber backing, flap valves were made that close automatically under pressure, and may be held open simply by propping up the flap. To eliminate leakage at low pressures, a 2-in bolt through the flap can be used to close the valves securely by placing a crossbar over the bolt and tightening the flap against the plate. The valves are fastened onto the tiles by means of wires put through the manholes and tightened with eyebolts.

Water-table observations were made in ⅜-in perforated pipe 4½ ft long placed in a regular pattern over the field (Fig. 2). They were loosely suspended in a 1-in bored hole. The water level in these pipes was recorded with the electrical reader developed in the department of agronomy at Iowa State College (10).

Operating Procedure

To operate the system, the water table was raised to within six inches of the surface. It was originally intended to apply the water by means of a sprinkler irrigation system. But it was found that the infiltration rate at the site was far too low, making this method impractical until a better vegetative cover has been established. Moreover, considerable trouble was encountered with entrapped air. Subsurface irrigation was found to be more satisfactory. Water was simply pumped into the large sump. It then flowed through the main into the smaller manholes and entered the soil through the tile lines. A surface ditch was provided to allow any excess water above a predetermined level to flow back to the interceptor ditch. In this manner a constant head could be applied. To counteract a tendency for the water to flow from the shallow tile through the loose backfill to the surface and cause partial surface flooding, this head was maintained about 6 in below the mean ground elevation by notching one manhole to the desired elevation.

After the water table had reached a satisfactory level, a reading was taken on all water table pipes, the time at the beginning and end of the set of readings being recorded. Then the manholes were pumped empty, the valves on the tile lines not being used were bolted shut, and those on the lines being studied were propped open. At regular time intervals, a set of readings was taken of the water table level and simultaneously the discharge from the tile lines was measured by noting with a stop watch the time required to fill a container of known volume. This procedure was continued as long as there was water in the majority of the water table pipes.

The fifteen tile lines offer a wide choice of spacings varying from 40 ft to 320 ft at two depths. However, as indicated in Table 1, in some cases valid discharge measurements cannot be made.

TABLE 1. POSSIBLE DEPTH AND SPACING COMBINATIONS FOR FIELD LABORATORY

Spacing	Tile lines open	Tile lines draining proper width	Number of replications: Water table shape	Number of replications: Discharge
		Depth of 4 Feet		
40	2, 4, 6, 8, 10 12, 14	4, 6, 8, 10, 12	6	5
80	2, 6, 10, 14	2, 6, 10, 14	4	4
120	2, 8, 14	8	2	1
160	4, 12	4, 12	2	2
200	4, 14 or	—	1	0
	2, 12	—	1	0
240	2, 14	—	1	0
320	8	8	1	1
		Depth of 2 Feet		
40	1, 3, 5, 7, 9 11, 13, 15	idem	8	8
80	1, 5, 9, 13 or	5, 9	3	2
	3, 7, 11, 15	7, 11	3	2
120	1, 7, 13 or	7, 13	2½	2
	3, 9, 15	3, 9	2½	2
160	3, 11 or	—	1	0
	5, 13	—	1	0
200	1, 11 or	11	1½	1
	3, 13 or	—	1	0
	5, 15	15	1½	1
240	1, 13 or	—	1	0
	3, 15	—	1	0
280	1, 15	—	1	0

Field Operation

The operation of the tank in the manner just described during the past season has revealed a number of surprises, and unfortunately has presented several difficulties which are as yet unsolved.

1 The time required to raise the water table was far longer than anticipated. It varied from about 8 hr to 30 hr, depending on the previous treatment. This delay required operation on a 24-hr per day basis and increased the cost of operation considerably, especially since, with the available 300-gpm pump, it was necessary to pump at a rate far greater than the rate at which the water entered the tank.

2 The rate of deep seepage loss was high, in fact high enough to cause a drop in the water table of about 3 iph with all tile lines closed. Batteries of piezometers installed at different distances from the barrier gave confidence that not much water was lost by leakage through or directly around the barrier. A number of leaks were discovered where the tile lines crossed the barrier, but these were repaired without any noticeable effect on the rate of drop of the water table. This deep seepage loss may at least partly be accounted for by the abnormally dry season. Even with a permeability of the subsoil very much less than in the upper strata, large losses can be expected if there is no water table surrounding the tank. Although there is no record of it, it is quite possible that there is a highly permeable layer at a considerable depth. With the natural water table down as far as this layer, the water within the upper layers could actually be under tension. The permeability at the site will be discussed later.

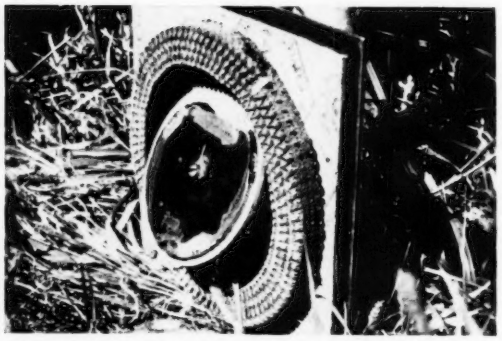

Fig. 3 Close-up view of valve before installation on end of tile line.

3 Difficulties were encountered in measuring the water table in that the pipes tended to fill with mud, making it difficult to follow the water table down much below two feet. Frequent removal and cleaning helped, but did not solve this problem. Burlap placed around the pipes should solve it, but has not been tried.

4 In many cases, the data show a nearly flat water table with the expected curvature only evident in the immediate neighborhood of the tiles. The loess soil shows definite signs of horizontal layering which suggests an anisotropic condition; this offers a possible explanation of the flat water tables. Flat water tables like these have been observed elsewhere (*e.g.* 12). While in some cases these could have been due to back pressure in the drain, such an explanation is not tenable here. If the horizontal and vertical components of the permeability are known, anisotropic conditions theoretically pose no particular problems, but practically they require increased accuracy in measurements for the same amount of information.

5 During the later runs, the temperature of the discharge water was periodically recorded. Whereas permeability is a true soil perameter, hydraulic conductivity is inversely proportional to viscosity, and the viscosity of the water changes about 15 percent for a 10 F change in temperature in the range generally found in the field. Unfortunately the importance of temperature was not recognized till fairly late in the season.

As an example of the type of data obtained, the results of one run, with 160-ft spacing and 4-ft depths, are presented. It will be recalled that for this case two tile lines (Nos. 4 and 12) are opened, and that each drains 160-ft so that the discharge is representative of the 160-ft spacing.

The curve showing the rate of drawndown midway between the tiles (Fig. 4) has a slope about 30 percent greater than for the seepage run with all tiles closed. It flattens out when the head decreases, as expected. Fig. 5 shows the shape of the water table at different times. This particular run was used as an illustration because it does show a significantly faster rate of drawndown than for the case of no tile drainage and also distinctly shows the drawdown over the tile lines. Unfortunately that was not true in every case. It also indicates that a number of pipes became plugged with mud. The discharge curves (Fig. 6) show a fast decrease in discharge rate at first. There is always some question as to how much of the initial discharge can be considered soil drainage water, and how much is really that stored in the tile line. The times of stopping the pump and opening the valves are shown.

Auxiliary Data

In addition to the experimental runs, an effort was made to determine the permeability characteristics and the porosity of the soil. Whereas most of the permeability measurements were made with the piezometer method, using 2-in piezometers, some auger hole permeabilities were also obtained and a few core samples were tested on a constant head permeameter.

The results of the piezometer studies show an apparent hydraulic conductivity of about 20 ft per day at depths from 3 to 5 ft, and a hydraulic conductivity of less than 1 ft per day at 5.5 ft. At a depth of 2.5 ft, the measurements showed great variation, but they averaged 10 ft per day. No reliable measurements have yet been made at greater depths.

Since anisotropic conditions were suspected, an attempt was made to separate the horizontal and vertical components of permeability through measurements at a depth of 2.5 ft. This can be done theoretically for a homogeneous anisotropic soil by first measuring the rate of flow into a piezometer when the tube is augered out even with the bottom, and then again after a cavity has been provided below the tube. An article to be published by Maasland and Kirkham will present the analytical details for this procedure §. The erratic nature of the measurements, however, made these calculations highly unreliable. Most of the variation, in the opinion of the authors, was caused by lack of control over the shape of the cavity. It is hoped that the use of larger diameter tubes will make it possible to eliminate at least part of this difficulty.

The piezometer measurements at 5½ ft and deeper brought out some other problems. Difficultes in driving the 10-ft pipes used caused a number of pipes to stand so loose in their holes that they could be shaken back and forth. Also, in augering out these pipes, the plug of soil at the end of the auger caused enough suction to pull some soil from below the pipes up into them. In some cases it was found that the soil level in the pipe was raised as much as one foot in this manner. Whatever the shape of the resulting cavity, it no doubt was far greater than the 4-in cylindrical cavity desired. The flow into these 10-ft pipes was considerably faster than anticipated. Leakage between the pipe wall and the soil and the excessive cavity size both contributed to the rapid flow. To alleviate the problem of suction, a hollow auger was made with a plug at the end which could be pushed down by means of a rod through the center of the auger shaft. When special care was taken in driving the pipe to avoid having loose standing pipe and the hollow auger was used, the hydraulic conductivity values obtained at 5.5 ft were very much lower and probably more nearly correct than those obtained before.

As was expected, the hydraulic conductivity as determined from undisturbed core samples was considerably lower than the value determined *in situ*. Moreover, the variability was extremely great.

The porosity was determined from the core samples. From the 24 cores tested to date, the percent porespace was found to be about 5 percent at 50-cm tension, and the total porespace about 55 percent.

Suggested Analysis

It is intended to determine the rate of drawdown as illustrated in Fig. 4, or the slope of the curve, for each of the depth and spacing combinations available and to subtract from this figure the rate of drawdown of the water table observed when all tiles were kept closed. These differences should be indicative of the effect of the tile lines

§ The appropriate A factors have been determined and are available at the agronomy department, Iowa State College.

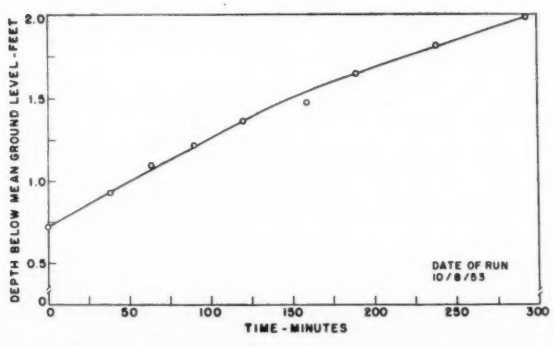

Fig. 4 Behavior of water table midway between tile lines spaced 160 feet apart and 4 feet deep.

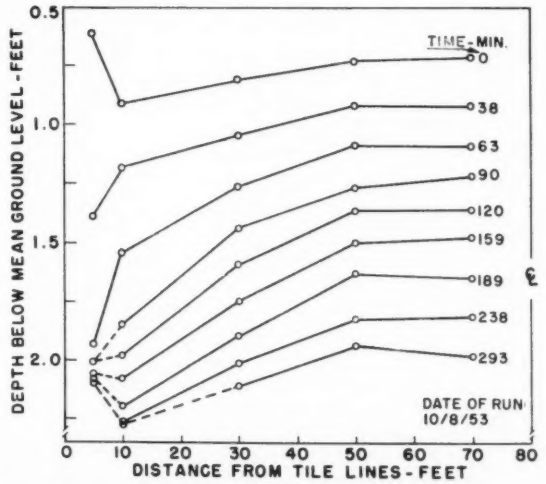

Fig. 5 Illustration of drawdown effect near tile lines for spacing of 160 feet and 4 foot depth. Dotted lines indicated mud in the observation wells.

since one may consider the complex potential simply as two additive potentials superimposed: that causing deep seepage and that caused by the tile lines.

Similarly, the volume of water drained by the tile system can be compared with the volume of soil drained. Assuming 5 percent drainable pore space, the difference between the two should represent the amount of water lost by deep seepage.

To the extent that the data have been analyzed, it appears that the effect of tile drainage as compared to deep seepage has been extremely small, i.e., on the order of 10 percent. Considering the accuracy of field measurements that can reasonably be obtained, such a large deep seepage effect constitutes a serious limitation of the usefulness of the field laboratory.

The field data have not yet been compared with theory. If an existing solution using the relaxation method can be found that has the appropriate dimensions when anisotropic conditions are taken into account, a comparison with that solution is very desirable. Whether one is justified to spend the time to originally solve the problem for each depth and spacing concerned, is doubtful. It will also be interesting to make a comparison between field data and formulas such as Aronovici and Donnan's.

Possible Future Studies

It is hoped that in the spring, when the natural ground water level is closer to the surface than in the summer, the rate of deep seepage will be sufficiently retarded so that better results may be obtained when repeat runs are made of the type discussed earlier.

So far a poor stand of timothy and alta fescue serves as cover for the plot. When a good stand of a close-growing grass has been obtained, the infiltration rate should be considerably higher than it is now. This may make it possible to use the irrigation system to represent rainfall, and to determine the equilibrium positions of the water table for given rates of rainfall and deep seepage and different depths and spacings of tile lines. Such a study would afford an excellent check on the work of Van Deemter which was discussed earlier, and as such would provide a basis for confidence, or lack of confidence, in the applicability of the theory. Whereas there is no reason to doubt the validity of the theory, it is quite possible that the assumptions on which the theory are based are not sufficiently realized in the field.

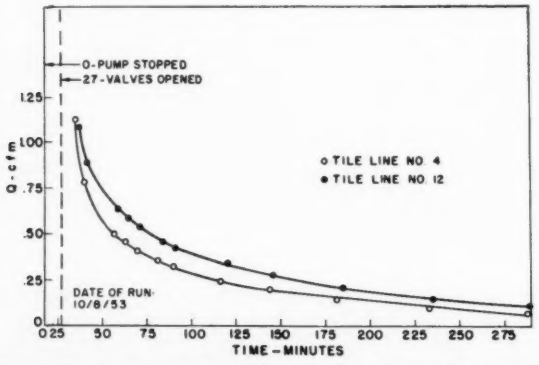

Fig. 6 Discharge curves for tile lines open during run at 160 foot spacing and 4 foot depth.

By using a larger number of observation wells near the tile lines, the behavior of the water table immediately around the tiles can be studied more fully. Since this is the area where the Dupuit-Forchheimer theory breaks down, such a study should be of interest.

It would have been desirable to make it possible to measure the total amount of water applied to the field. This would facilitate the determination of the deep seepage rate and also make studies of evapotranspiration rates possible. Unfortunately, with the open tile main and unsealed manholes of the present system, this cannot be done.

Summary

A field tile drainage laboratory, consisting of an area underlain by a relatively impermeable layer and surrounded with a sheet metal barrier, has been installed in western Iowa. Tile lines have been placed in such a manner that the behavior of the water table can be observed for eight different spacings and two depths of the drains. Representative discharge measurements may be made for most of the depth and spacing combinations. Water can be applied to the area either by sprinkler irrigation or by subirrigation through the tile system.

Practical problems encountered in the construction and operation of the system are described. Samples of data are presented, together with some of the results of the permeability and porosity determinations.

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Balancing Agricultural Engineering Research

Harry B. Walker
Fellow ASAE

Broader Horizons and Expanded Liaison Between Research Organizations the Great Need

A VIRILE nation is the product of the wisdom of its people. Nations which utilize their human and material resources intelligently reflect a high standard of living for their citizens, and this may be measured by such mundane things as the per capita consumption of steel. An aggressive people requires constantly more power and more materials for its application and use. These requirements are met basically through the engineering sciences. Material demands cause engineering scientists to explore and exploit the resources and forces of nature, which in time may lead to the exhaustion of specific resources and the development of entirely new ones. This causes evolutionary changes to take place through the resourcefulness, initiative, imagination and industry of man aided by science. Our frontiers are advanced principally through research. It is a requirement of the age in which we live.

We, as agricultural engineers, are concerned with a segment of this frontier. Through the tools of engineering science our specific purpose is to advance agriculture, not only for its own benefit, but for society as a whole. Our research programs must be kept in balance with the needs of the times if we are to fulfill our obligations to society.

What are our concepts of research, and how shall we evaluate our efforts in it? Broadly speaking, we normally divide research into two general groups, fundamental and applied. For the purposes of this discussion it is proposed to divide research into five categories, as follows: pure, basic, applied, development, and consumer.

Each of these divisions is important in itself, but only one, pure research, is entirely original and independent of the others. It is in pure research that the origin of all other research lies. It is the area of investigation where great individuals without specific objectives, or thought of economic implications, conceive and discover new relationships in nature. Men who make such contributions to knowledge are rare, but the value of their contributions is great and essential for progress.

Basic research has greater objectivity than is found in pure research. It broadens knowledge and builds it into more specific forms for usefulness. Thus pure and basic research, while different in themselves, together constitute fundamental research. Fundamental, by definition, means: foundation, groundwork, indispensable, primary; basic of a system as a truth, law, or principle. It constitutes the development of essential knowledge. Unless this area of research is kept alive and active, sources of knowledge dry up, and new applications cease.

Engineers should have a broad concept of basic research. The concept of Dr. Ralph A. Morgen, director, division of engineering sciences, National Science Foundation, should be of interest. In emphasizing the need for balancing the nation's research, he stated (1)*:

"At this point it is pertinent to note that there is a field of basic research, fundamental studies in the engineering sciences, which is often overlooked. Research by physicists, chemists, or biologists many times stops far short of the point where the new idea can be useful for military or commercial exploitation. Basic information in the engineering sciences (such as fluid mechanics, heat transfer, structures, and unit operations) is needed to bridge the gap. Often this type of research is mistakenly considered as 'applied research,' but it is a misconception to neglect this vital area of fundamental research." This is a concept that we, as engineers, should embrace. One should not expect engineers to do very much in the area of pure research, but we should expect engineers to do research in bridging the gap between pure science and its application.

It is estimated that about one-half of all the funds spent for research by non-profit institutions is for applied work. This seems to be a high proportion, since progress depends upon knowledge acquired from more fundamental studies. Non-profit institutions serving agriculture must put considerable effort into applied research. The nature of agriculture is such that a lot of pioneering effort in experiment stations is required to introduce and establish a new crop, or a new method of handling or processing of established crops. Often this sort of research must take place before industry can be induced to serve the farmer with new types of equipment or facilities. On the other hand, here is a fertile field for cooperation between non-profit institutions and industrial groups.

Following applied research comes development. This is an area in which industry, by the very nature of its service, is extremely effective. A sound economic practice or service once established requires a lot of development to make it more efficient and useful. Thus development is a primary function of industry. Today, it would seem that engineers in non-profit institutions might render greatest service by defining the control problems and setting the critical limits of unit operations for quality and

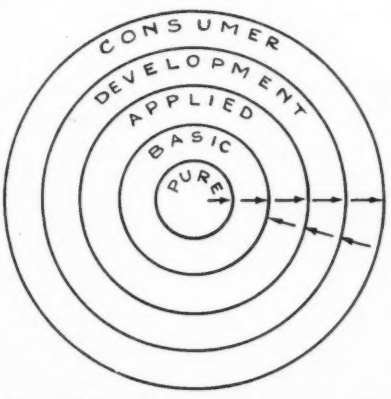

Fig. 1 Relationship between the five categories of research

Abridgment of an address at a dinner in Chicago, December 8, 1953, sponsored by the Research Committee of the Farm Equipment Institute, for leaders in agricultural engineering research in public service agencies. A limited number of copies of the complete address, printed separately, are available on request to the Farm Equipment Institute, 608 S. Dearborn St., Chicago 5, Ill.

The author—HARRY B. WALKER—is professor of agricultural engineering emeritus, University of California, a past-president of ASAE, and the 1939 recipient of the John Deere Gold Medal.

*Numbers in parentheses refer to the appended bibliography.

efficiency, rather than to put much effort into the development of complete machines. Industries, when supplied with basic control data, are able to proceed with considerable confidence and speed in machine development to meet the needs of farmers. To my way of thinking, development research in non-profit institutions involves peculiar responsibilities. Basically, it belongs to industry; but there are times when non-profit institutions must engage in it, as when new crops are developed, new market restrictions arise, new pests develop, and economic conditions undergo radical change. On the other hand, it affords opportunity for greater cooperation between industry and non-profit institutions than now occurs. Just as basic research is required to transform pure science into the applied form, so also development research is essential to translate applied research into successful practices. Certainly this is an area of mutual interest between industry and our public-supported research institutions.

The last step in the broad field of research is that relating to the consumer. Its purpose is to sample consumer reaction to a development. It is a measuring stick for determining the practical acceptance of an innovation. It often reveals the shortcomings of a development and may uncover ways to overcome these. Manufacturing industries through their sales and service departments carry on consumer research more or less automatically. As such it is an essential practice for product improvement and the maintenance of market positions. But this is not the case with non-profit institutions. They use them to discover and to define roughly controls in a practice, or operation, or as a means to develop quickly needed subject matter. For them, they should be considered normally as a preliminary to other investigations of a more profound nature. As such they are justified and often necessary. On the other hand, non-profit institutions cannot justify at this time many such activities as a complete means to an end in research.

The entire gamut of research extending from pure to consumer research has now been outlined. These different areas and their relationships to each other can be illustrated with an archery target (Fig. 1).

In the center, the bull's eye represents pure research, to be encircled by the ring of basic research. This is the area which must be developed to form the bridge to reach applied research. After the ring of application comes development, which is encircled in turn by the ring of consumer research. Generally, we may say the lines of scientific force originate at the center and extend radially toward the perimeter.

Non-profit institutions, particularly those that are tax-supported, must be concerned with the increase of knowledge. Accordingly, they must accept responsibility for fundamental research. Dr. Ralph A. Morgen (1) of the National Science Foundation states: "... the prime interest of the university in science is basic research — that type of research which is directed solely toward the increase of knowledge in science." Then he continues: "But this is not the case. ... The National Science Statistical compilation shows that non-profit institutions are now dividing their scientific activities approximately as follows: twenty-five percent for basic research; fifty percent for applied research, and twenty-five percent for development." (Fig. 2.)

The statement by Dr. Morgen stimulated a review of our research situation as of 1926-28 in comparison to our research situation in 1952-53. Naturally such an evaluation must be personal as well as more or less speculative. However, in preparation of the report issued in 1928 on "Research in Mechanical Farm Equipment" (2) a good opportunity was afforded to appraise the agricultural engineering research activities of that time. These evaluations (Fig. 3) are made for the five areas of research previously discussed and are expressed in percent of funds available.

In 1926-28 our efforts were relatively juvenile and our workers inexperienced. It was natural that much time should be spent on surveys, and the application of machines to tasks, such as were required to change farming operations from animal to mechanical power. Some basic research was under way, relating to the dynamics of machines, soil dynamics, duty of water and the like, but very few, among the 211 staff members in agricultural engineering of that time, had a clear concept of their research responsibilities, and many were not adequately trained to do profound research.

In attempting to make an evaluation of present-day research in agricultural engineering, it was necessary to rely upon a review of research reported through AGRICULTURAL ENGINEERING, and upon observations from visits to a number of institutions in recent years. Accordingly, these appraisals may have some personal bias. For purposes of stimulating our thinking of research balance, they are offered in the hope they may be useful. The following (Fig. 4) are

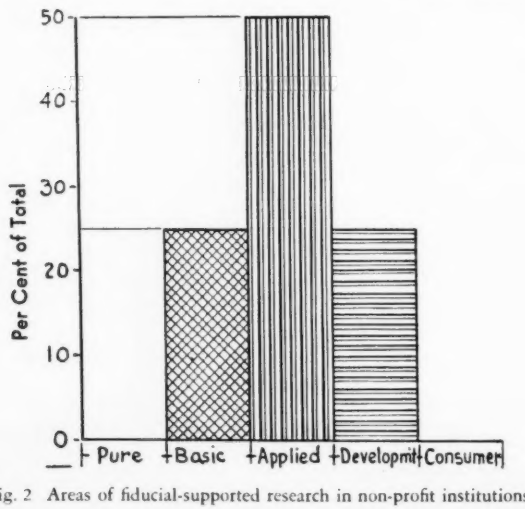

Fig. 2 Areas of fiducial-supported research in non-profit institutions

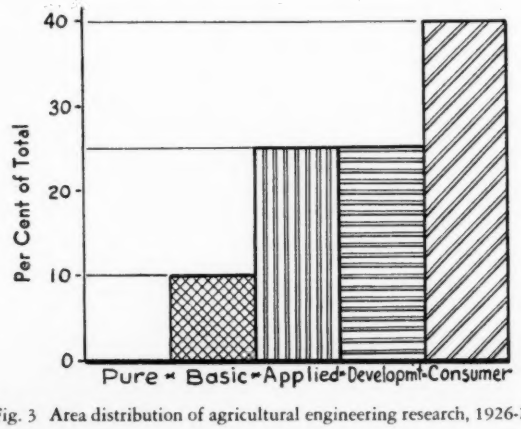

Fig. 3 Area distribution of agricultural engineering research, 1926-28

comparable estimates for the year 1952-53. These estimates indicate a shift toward more basic work even though the percentage still is relatively small. The nature of research problems in agricultural engineering tends to be in the direction of application and development. Engineers, moreover, due to the nature of their work, are likely to be more concerned with the application of science than with its purity. This, however, does not provide a valid reason for the neglect of basic research needed for future engineering progress. Non-profit institutions are the only agencies the public has for the development of new knowledge. No other organizations are so well equipped and staffed with such a diversified and competent personnel, nor do they have as favorable environments for basic research.

What then may be some of the more important reasons why we, as agricultural engineers, do so little relatively in basic research? Some of the more important reasons are mentioned.

1 Basically, agricultural engineering constitutes an applied science field. The estimate of 15 percent in basic research is not too bad, if one takes as a measuring stick the National Research Foundation's appraisal of 25 percent for all non-profit institutions in the nation. But this is not a valid alibi. We dare not become traditional, or scientifically lifeless, which surely will be the case without the development of new knowledge. While our contributions to present-day progress have been noteworthy, can we continue to maintain our present pace and meet the future needs of agriculture without giving more attention to basic studies?

2 Progress in agricultural engineering to date has been attained principally by the labor-saving route. This has involved the application of machines to operations formerly done by human and animal power. This has called not only for applied research, but also for development and surveys of practice. During the past twenty-five years our experiment stations have spent considerable effort on equipment development, such as refrigerators, hay driers, beet harvesters, cotton harvesters, forage choppers, and the like. This has been justified, but the question may be raised now, if agriculture and the industries serving agriculture might not be better served if more attention were devoted to basic studies relating to product quality, reduction of waste, dynamics of machines, fluid mechanics problems, unit operations, and the like rather than direct machine development and labor saving.

3 It has been easier intellectually and financially to carry on applied and development research. A strong demand for subject matter has been created, and this tends to encourage quick, short-cut methods of obtaining it. Most academic-minded folks want to do research because they are interested in creating new subject matter. It should be a primary objective in equipping for basic research to assemble staffs of great ability and high academic achievement. Surely our non-profit institutions, if they are to fulfill their responsibility for creating new knowledge, must assemble staffs containing a goodly number of highly trained men.

4 Could it be that agricultural engineering personnel in our non-profit institutions has grown faster in number than in academic and scientific competency? This is not a pleasant question to contemplate. It is too personal. Throughout these institutions there is great staff industry and sincerity of purpose. These are virtues which make up for many dificiencies, but for basic research, men of superior ability and advanced training are required.

5 Duplication of research effort may be a related factor. Most of the agricultural engineering staffs have strong loyalties and a keen sense of responsibility to agriculture in their respective states. This often contributes to the solution of specific problems with some neglect of the generalization of knowledge. While some repetition of research effort is valuable and needed, it should not be carried to excess. Should we not devote more effort to the generalization of our findings in order to make them more adaptable to other areas? If this were done, it would make much of our applied research more basic in nature.

6 In a keen desire to serve agriculture, have we neglected to appraise both qualitatively and quantitatively the research potentials of industry? Those who work with or visit with industries serving agriculture must be impressed with the quality and growth of industrial research. In the larger industries the engineering and research personnel is the equal of that found in the better non-profit institutions, and the facilities for investigations are excellent.

Thus the research boundary lines between industry and non-profit institutions, after all, are not too indefinite. If only non-profit institutions are equipped best to do certain areas of research, then it would seem these particular areas become basic, or semibasic in nature. If other areas can best be done by industry, then these are very likely to be classified as applied and development research. A logical way to avoid duplication and overstepping of these somewhat ob-

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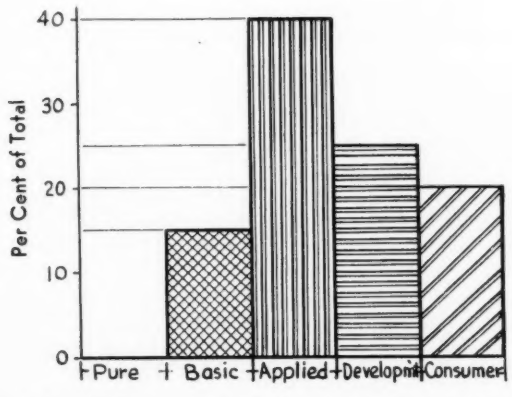

Fig. 4 Area distribution of agricultural engineering research, 1952-53

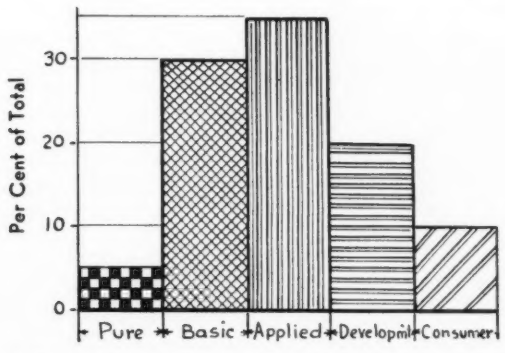

Fig. 5 Suggested pattern for areas of agricultural engineering research

Land Drainage in California

Walter W. Weir
Member ASAE

A Century of History-Making Drainage-Engineering Development

INTEREST in agriculture in California began with the Gold Rush in 1849. Prior to that time there was an important livestock industry in the state, but lack of rapid transportation to the east restricted this industry to the production of hides. As soon as the production of food for the miners became an important undertaking, the need for land drainage became apparent.

Drainage activity in California can be easily divided into three distinct and important epochs. If one considers the broader and more comprehensive meaning of the term "drainage," it becomes readily apparent what an important part it has played in the agricultural growth of the state.

The main line of communication between San Francisco and the gold fields was through either Sacramento or Stockton. In order to get to either place, travelers, on foot or horseback, were forced to detour around the Delta or, if by boat, to pass through the Delta.

The importance of this region, and its agricultural possibilities, was early brought to the attention of persons interested in feeding the miners.

A tremendous stimulus was given to the development of the Delta when Congress passed the Swamp and Overflow Act in 1850. By this act, all government-owned swamp and overflow lands were transferred to the state in which they were located.

The strategic importance of the Delta as an agricultural area, together with the cheap lands which the state was practically giving away, stimulated the reclamation of these swampy lands. Within a few years practically all of this land passed into private ownership. Thus began a very important period in California's drainage history.

FIRST PERIOD

The first reclamation district in California was in the Delta area. Between 1860 and 1870 about 100 reclamation districts were organized. By 1900 the number had increased to 700. These districts were widely scattered over the state.

During *each* of the three years, 1874-5-6, more than 40 reclamation districts were organized, a total of 129 in three years.

Most of these districts were organized by special acts of the legislature rather than under the reclamation district enabling act. Although most of the districts organized during these early years no longer exist as separate organizations, the land is still included in some reclamation districts.

Reclamation District 2047, in Glenn and Colusa Counties, is the largest in the state, almost 230,000 acres. When it was organized in 1920, it absorbed or included 26 smaller reclamation, levee, and irrigation districts.

The Reclamation District Act permits a broad interpretation of the word "reclamation"; almost anything can be done in a district organized under this law. It can construct drains, build levees, irrigation facilities, pumping plants, et cetera.

With the rapid expansion of reclamation districts, and the construction of levees for the control of floods along the major streams, it was found necessary to have some coordination and control over the location and height of the levees. The state reclamation board was created and an over-all district was organized to cover all of the reclamation and levee districts, in both the Sacramento and San Joaquin valleys. Thus the Sacramento-San Joaquin Drainage District, extending nearly 350 miles from Red Bluff to Bakersfield, was organized. Through this organization the State Reclamation Board had an assessment district to raise funds with which to support the coordinated program of leeves and by-passes.

The control of floods from the Sacramento River and its tributaries has resulted in one of the most complicated and interesting levee and by-pass systems to be found anywhere in the United States.

The Sacramento River, as it flows past the city of Sacramento, has a capacity of not more than one-third of the maximum flood runoff from the area drained by it. The river channel at Sacramento has less capacity than it has 150 miles north, at Redding. In this distance there are three major streams — the Feather, Yuba, and American rivers as well as a half dozen minor streams, which are tributary. None of the streams south of Stony Creek are permitted to enter the Sacramento river, but discharge into the adjoining basin areas.

In order to relieve the Sacramento River of some of its flood flow at Colusa, 150 miles north of the city of Sacramento, the Moulton weir was placed in the levee and part of the flow taken out of the river and discharged into Butte Basin. This water from the river joins the flood from Butte Creek, and both are carried around the west side of the Marysville Buttes through the Butte by-pass, then into the upper end of Sutter basin, where it is picked up by the Sutter by-pass. About 15 miles south of Colusa, the channel of the Sacramento River again becomes too small to carry its flood waters, and more water is taken out through the Tisdale weir and by-pass, and dumped into the Sutter by-pass.

The Sutter by-pass carries these flood waters along higher ground east of the trough of Sutter Basin and leaves the more desirable soils in the three reclamation districts—Nos. 70, 1660, and 1500 — available for cultivation. This was a major undertaking and reclaimed about 100,000 acres of good land.

There is considerable of Feather River water used for irrigation in northern Sutter County, the waste from which drains around the east side of the Buttes. This water is intercepted and picked up by the East and West Intercepting Drain, and the Wadsworth Canal, and discharged into the Sutter by-pass about 5 miles south of Sutter City.

The Feather River is joined by the Yuba at Marysville and the Bear just above Nicholas. Ten miles northeast of Knights Landing the Feather River joins Sutter by-pass, through which all of the accumulated flow is carried a dis-

This paper was presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Stockton, Calif., January, 1954.

The author—WALTER W. WEIR—is drainage engineer, University of California.

tance of about 8 miles to the Sacramento River. The levees which delineate the Sutter by-pass are about two miles apart at this point. The flow through the Sutter by-pass enters the Sacramento River over the north half of the Freemont weir, only to be taken out again over the south half of the Freemont weir into the upper Yolo Basin. Thus for all interests and purposes the water is carried across the Sacramento River from the Sutter Basin to the Yolo Basin.

On the west side of the Sacramento Valley, from just above Willows to Knights Landing, a distance of about 60 miles, there are two large reclamation districts — 2047 and 108 — comprising over 250,000 acres. All of the drainage from this area, including the runoff from a number of small creeks, which have their source in the Coast Range Mountains to the west, flows southward through a series of enlarged sloughs and drainage ditches in Colusa basin. This water is prevented from entering the Sacramento River because of the levees, consequently it is backed up against the high alluvial fan of Cache Creek, which is known as the Knights Landing Ridge. In order to overcome this difficulty a deep, wide channel, about 7 or 8 miles long, known as the Knights Landing Ridge cut, was dug across the ridge thus permitting this water from the west side to flow into Yolo Basin. At this point it joins the floods carried by Sutter by-pass, which, as has been mentioned, have crossed the Sacramento through the *double* Fremont weir.

From the upper end of Yolo Basin to Rio Vista, a distance of about 40 miles, the flood waters are carried between levees which form the Yolo by-pass. The Yolo by-pass has several times the capacity of the Sacramento River.

Notwithstanding the fact that no water is allowed to enter the Sacramento below Orland, and that there are three weirs above the mouth of the Feather River, which take water from the Sacramento, the channel is still not large enough to take care of the American River, which joins the Sacramento at the city of Sacramento. The American weir and by-pass, about two miles north of the junction, takes water out of the Sacramento and dumps it into the Yolo by-pass. At Rio Vista the Yolo by-pass empties back into the Sacramento, and from there to the head of Suisuin Bay the leveed river channel is large enough to take the entire flood.

This by-pass and levee system was completed in the late 1920's, and at about the same time the organization of reclamation districts came to a standstill. This ended the first of the three important epochs of drainage activity in California. Incidentally, the author's first job after finishing school in 1907 was on the reconstruction of the west levee of the Feather River between Oroville and Marysville. This levee had been seriously damaged by the floods which occurred during the spring of that year.

The money that has been spent by the reclamation and levee districts of California for drainage and flood control must run into hundreds of millions. On the other hand, there have been millions of acres of fertile land brought into production. The quarter of a million acres in the Delta alone, all of which was once worthless swamp, produce annually more than 25 million dollars worth of asparagus, potatoes, and other crops.

SECOND PERIOD

The second period of interest in drainage began about 70 years ago, and is closely associated with irrigation. As early as 1886, Hilgard, in a report of the California Experiment Station, called attention to the need for drainage and alkali reclamation in the San Joaquin valley.

Prior to any irrigation in this region the ground water table is said to have been 40 to 80 ft below the surface, but with the rapid increase in the irrigated acreage, and the lavish use of water, the water table rose until it was within capillary distance of the surface and, after a few years, the salt accumulations were more than plants could stand. Vineyards and orchards were replaced by alfalfa. Alfalfa was replaced by grain and grain hay, and finally by Bermuda grass and saltgrass pasture. In the eastern half of the San Joaquin Valley, the soils contain sodium carbonate or black alkali, and this further complicated the problem. Sodium chloride or sulfate is bad enough, but drainage of black alkali lands is a real problem.

Hilgard sensed the importance of drainage and the use of gypsum to change black alkali to white alkali, but had little success in getting anyone to follow his advice. In 1902, Elliott, who was then head of drainage investigation in the U.S. Department of Agriculture, came to California and made a survey of about 25 square miles around Fresno, and designed a drainage system consisting of tile and open ditches. He succeeded in getting a few short, experimental drains installed. The ditches filled up and the tile ceased to function; hence the experiment proved to be a failure. None of those who tried drainage during the next 10 or 15 years had had any experience with the drainage of irrigated land. The techniques which they had used in humid areas did not work in irrigated areas. Mackie tried it in 1907, and Fortier in 1909, all on a small scale and all without a full appreciation of the fact that the drainage of lands in which the water table rises from below is different from that on lands which become wet from the top.

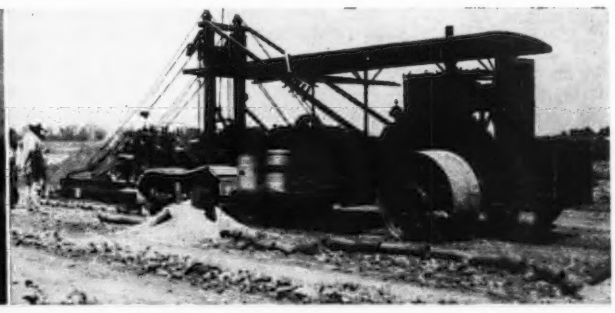

Fig. 1 *(Left)* Drainage water pumped from deep well is discharged in concrete-lined irrigation canals for reuse • Fig. 2 *(Right)* Heavy trenching equipment is required for placing tile drains 6 to 8 ft deep in California's irrigated areas

In 1913, when the author first entered the drainage picture in California, practically all of the irrigated lands of the San Joaquin Valley were threatened with abandonment. Eighty thousand acres of once fine land had a ground water table within six feet of the surface, and over half of that was within three feet of the surface. Water stood in the railroad underpass in the city of Fresno.

I was brought down from Yakima, Wash., where I was working on the drainage of irrigated lands, to supervise the drainage of 5,000 acres at Kearney Vineyard west of Fresno. This was property owned by the University of California. Although I had probably had more experience with the drainage of irrigated and alkali land than anyone who had previously tried it in California, I did not succeed much better than my predecessors, but I did have the backing of the agricultural station staff of the University, and we began to find out why we had failed.

In most cases irrigated lands became water-logged from the bottom up. Water tables that may originally have been 40 to 80 ft from the surface rose to the surface. In other words, the deeper one goes, the wetter the soils become, whereas in humid areas the wettest part of the soil is the surface. When we began to appreciate this difference, it became apparent that we had to dry the lands out from the bottom.

The solution to this is very largely one of deeper drains and the maintenance of a water table much lower than had previously been considered necessary. This, however, is not so simple as it sounds. Installing drains—either open ditches or tile — to maintain a water table at 6 to 8 ft becomes a problem in construction.

Along about 1915 or 1916, the engineers in charge of the Salt River project in Arizona conceived the idea that it would be possible to lower the water table in the poorly drained portions of the Salt River Valley by pumping from an underground pervious strata. After overcoming a high degree of skepticism on the part of the directors of the Salt River project, a few deep wells were installed. The real purpose of these wells was disguised under the pretext that they were for irrigation purposes, but after they were completed they were operated as drainage wells. These wells proved to be so effective in lowering the water table that the engineers were encouraged to install more of them, and thus an entirely new method of drainage was born.

Our California engineers flocked down to Arizona to find out firsthand what was going on, and within a short time, Turlock, Modesto, Merced, Fresno, and South San Joaquin Irrigation Districts began installing drainage wells and pumps. By 1924 there were between 175 and 200 deep-well pumping plants in the San Joaquin Valley, installed and operated by the irrigation districts solely for drainage purposes. Thus, almost over night, the whole drainage problem in the San Joaquin Valley was changed from one of despair to one of optimism.

It was soon discovered that the water pumped from a drainage well was just as good — in fact, the same as that pumped from an irrigation well — so the water was turned into the irrigation canals for re-use, thus eliminating the necessity for any special means of disposal.

Since that time, there has been a real need for more irrigation water, and now there are more than 60,000 irrigation wells in the San Joaquin Valley. The water table has dropped well below the danger point and, only in a few cases, is there need for drainage. The need for more irrigation water has, of course, been an important factor in the San Joaquin Valley. I think it is safe to say that any irrigated area that has all of the gravity water it needs has too much, and will eventually have a drainage problem. Those areas that need more water and must resort to pumping are reasonably safe.

There are some important differences between pumping for drainage and pumping for irrigation. The ideal irrigation well is one that will deliver a large quantity of water with a low pumping lift. The ideal drainage well is one that also will deliver a large quantity of water, but it requires a relatively high lift to get it. It must have both discharge and drawdown; one without the other would not produce satisfactory conditions for drainage. A drainage well should be pumped continuously for a minimum of 180 days each year.

For purely psychological reasons, it is essential that pumped drainage water be put to beneficial use if the pumps are to be effectively operated. No one seems to care about water collected in drain ditches or tile. That can be wasted, but not so with pumped water. In general, drainage by pumping from wells is the cheapest of any method yet used on irrigated land. In the Turlock district, 90 cents spent in pumping costs produces a dollar's worth of irrigation water.

THIRD PERIOD

The third period in drainage history is dawning, and it may develop into something at least as important as the second period. Until recently the use of tile for drainage in California has been sporadic. This is probably due to the fact that most of our drainage problems have been community affairs rather than the drainage of individual farms.

To a large extent, organized districts have provided outlets into which the individual farm drains may be discharged. Farmers now want better drainage than the community, or district drains can provide, and they are willing to pay for it. A very striking example of this is in the Imperial Valley.

In 1912 the East Side High Line canal was completed in Imperial Valley. This canal added about one-third to the irrigation acreage in the valley, most of which was in an area of medium to light-textured soils. Two years after this canal was completed the water table rose, and high concentrations of salts accumulated in the area between the canal and the Alamo River. Not only here, but throughout a considerable part of the valley, drainage trouble developed rapidly so that by 1915 the mutual water companies, which were then distributing the irrigation water, began to construct open drainage canals within their territories. There were thirteen of these mutual companies and it was soon found that drains had to cross the lines from one company's domain to another.

In 1919 I made a report on drainage in this valley and recommended the organization of an over-all district for the valley so that there could be better coordination in planning drainage and spreading the costs. A couple of years later the Imperial Irrigation District absorbed the mutual water companies and almost immediately started a valley-wide drainage campaign. Deep, open drains, ranging from 10 to 12 ft deep, were constructed and several million dollars in irrigation district bonds were issued to pay for them. Although

more than 1300 miles of drains were dug, about all they did was to furnish outlets for further work on the individual farm. At the present time, every farm has a deep open drain, at least 8 ft deep, into which it can discharge.

To my mind the most difficult drainage problem in the state was in the Imperial Valley. Tile drains had not been very successful. Pumping from deep wells was ineffective, because none of the conditions found necessary to success by pumping existed in the Valley.

In 1940 the research division of the U.S. Soil Conservation Service entered the field and spent the next 10 years in an intensive study of the problem and finally arrived at a tile drainage formula which worked. These studies were directed by a special committee of which I was a member. More than $100,000 was spent on this study, a large part of which was furnished by the Imperial Irrigation District.

As a result, the farmers of Imperial Valley have launched a tile drainage program, which has produced wonderful results. During the past five or six years, more than 4500 miles of draintile have been placed. During 1952, which is the last year for which the figures have been compiled, 798.38 miles of tile were installed. This is an average of 2.18 miles per day for every day of the year. These drains are on individual farms paid for by the farmer. There have been six tile-laying outfits operating in the Valley. With the present prices for farm products, some farmers have paid the entire cost of drainage, which averages about $85 per acre, from the increase in production in one year.

GROWING INTEREST IN TILE DRAINAGE

Although this is by far the most important current drainage activity in the state, there has been a growing interest in the use of tile elsewhere. Several interesting deep-tile systems have been installed and more are contemplated in the Sacramento Valley. Drainage by tile in this state has introduced some new concepts into the design of drainage systems. The old rules on depth, spacing, and discharge must be revised.

In Imperial Valley drainage systems are designed to discharge about ⅓ cfs per mile of tile, thus making 4-, 6-, and 8-in tile about the only sizes used. On the other hand, one tile system along the Sacramento River has a discharge of 4 cfs per mile, or 12 times that of Imperial Valley. In this system the tile lines are between 10 and 12 ft deep.

The standard trenching machines, made in the eastern part of the country, are not large enough for our work. They should have a digging depth of not less than 8 ft.

The modern excavator, which is capable of digging a trench 8 ft deep, carries a steel shoe which extends about 6 ft back of the cutting mechanism to hold the trench open until the tile is placed and covered. The tile layer sits in the shoe, places the tile on a bed of gravel, and holds it in place with his foot while a strip of paper, and then another layer of gravel, is placed over and around the tile. The gravel below, and the paper and gravel over the tile, are all placed automatically. The trench is filled immediately behind machine.

In Imperial Valley, and on large jobs elsewhere in California, the manufacturers of draintile do not sell tile to the farmer, but rather they sell a completed drainage system, doing all of the work themselves.

We are not yet fully into this third epoch in California drainage, but I think that the use of tile on individual farms will develop into a history-making period. The price of draintile in the northern part of the state is a deterring factor at present.

Balancing Research

(Continued from page 481)

scure boundaries is to maintain a close and understanding cooperation between these groups. It is no sin for industry to seek needed information from non-profit institutions, but it is a sin for these institutions to do research which industry can do as well or better for itself.

The land-grant institutions, cooperating with the USDA, have the opportunity to improve the quality of their research in agricultural engineering. It should be admitted that personnel deficiencies exist for the conduct of basic research. Furthermore, the research programs should be revised with the objective of making them as basic as possible for the development of new knowledge needed for the continued advancement of our agriculture. If industry is to get the research information it needs and wants, there must be a willingness upon its part to assume responsibility for much of the applied, development, and consumer phases of research relating to its activities. This calls for a sharing of information, and a need upon the part of industry to define the specific research needs confronting them in meeting the equipment needs of farmers. This is the "liaison service required between research and industry" referred to by the Secretary of Agriculture (3). The work of the Agricultural Research Committee of the Farm Equipment Institute is indicative of what may be done to provide this "liaison service." It can be made even more direct and effective when supported by research grants, fellowships for advanced students, and outright cooperation on projects of mutual interest.

The research study of 1926-28 was productive and helpful, but it is now 25 years old. To my way of thinking, another such study should be made in the research climate of 1954. What are the basic research problems of today and how well are we prepared to meet them? Are we making provision for the needed new knowledge in the years to come?

In view of these statements you may wish to know what I would consider as a more balanced research program. The following distribution would seem to be more creditable for agricultural engineering in non-profit institutions in the light of present-day industrial research developments and the future needs of both agriculture and the industries serving agriculture (Fig. 5):

Area of research	Percentage of funds
Pure*	5.0
Basic	30.0
Applied	35.0
Development	20.0
Consumer	10.0

*Limited largely to academic research conducted by men qualifying for a doctorate.

Certainly we will not be criticized for improving our research program, but most surely criticism will come if a search for new knowledge is not attempted. Let us organize now to obtain this new knowledge, and may we have a greatly expanded liaison service between research and industry in order to make our efforts most effective.

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Rapid Methods of Determining Soil Moisture

James E. Garton and Frank R. Crow
Assoc. Member ASAE Member ASAE

IN THIS paper is reported three methods of rapidly determining moisture content of soil samples, as developed in a research program conducted by the authors. The conventional soils oven method of determining soil moisture requires considerable oven space and time when a number of samples are to be dried. A fast and accurate method of determining the moisture of samples would help in any irrigation research program.

Research in engineering and other phases of irrigation is conducted at the Irrigation Experiment Station at Altus, Okla. Satisfactory yields on variety and fertilizer plots can be obtained if the Foard clay loam soil is irrigated before the soil moisture in the 6 to 12-in zone is reduced to 16 percent. Therefore, in these plots the time of application is based on the moisture content of the soil.

Extremely hot, dry winds during the summer months cause the soil moisture to be depleted rapidly. The irrigation water is delivered by the district on a modified demand system in which at least 24 hr and as many as 48 hr may elapse from the time the order is turned in until water is delivered. Since the time of application is critical, it was desired to reduce the time interval between taking the soil samples and ordering the water. These circumstances led to the search for a more rapid method of determining soil moisture. There are two possible methods of speeding up the process. One is to eliminate drying, and the other is to dry faster. The methods tested were the limit sampler, the pycnometer, and the infrared oven.

Limit Sampler Method

Fig. 1 shows the sampler. The distinguishing feature of this sample tube is the adjustable stop which determines the size of the sample taken.

If a group of samples can be taken which has an average oven dry weight of 100 g, the equation for soil moisture percent is

$$P_w = \frac{\text{Wet weight} - 100}{100} \times 100 \quad \text{.....[1]}$$

or the wet weight minus 100 g. After the sampler has been adjusted to take samples with an average dry weight of 100 g, the average moisture percent at the depth sampled can be found without drying the samples. Samples with dry weights which are multiples of 100 g can also be used.

Setting the sampler to obtain a group of samples with an average dry weight of 200 g proved to be most difficult. The mean difference between the moisture percent determined by the limit sampler and the moisture percent determined by the soils oven was too large (3.8 percent) to recommend the use of the limit sampler. About one hour was required to take 10 samples.

Pycnometer Method

Tortensson and Eriksson* in 1936 presented a method of determining soil moisture by using a porosimeter; therefore, a variation of their method was tried after the limit sampler had been found unsatisfactory. Tests were run with a pycnometer and a set of laboratory trip balances to obtain the basic data, and the equation suggested by Tortensson and Eriksson was manipulated so that a simple graphic plot could be obtained. The pycnometer consisted of 150-cc laboratory bottle equipped with an aluminum stopper with a hole drilled through it.

*Tortensson, G. and Eriksson, S. A new method of determining the porosity of the soil. *Soil Sci.* 42 : 402-417, 1936.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1953, as a contribution of the Power and Machinery Division.

The authors — JAMES E. GARTON and FRANK R. CROW — are assistant professors of agricultural engineering, Oklahoma A. and M. College.

Acknowledgement: The authors are grateful for the assistance of Carl Marshall, director of the statistical laboratory, Oklahoma A. and M. College, in setting up the pycnometer experiment and statistically analyzing the data. They also acknowledge the assistance of Fred J. Oppel, Jr., Roy L. Goodman, and W. O. Mack, former students in the department of agricultural engineering, in gathering some of the data used in this paper.

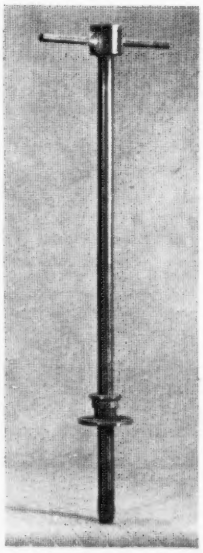

Fig. 1 Limit sampler showing adjustable stop

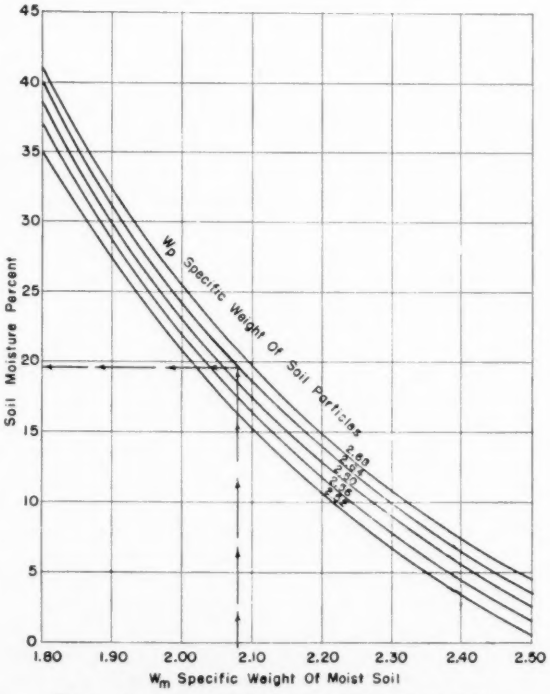

Fig. 2 Soil moisture versus specific weight of moist soil

The equation for determining soil moisture is

$$P_w = \frac{W_p - W_m}{W_p\,(W_m - 1)} \times 100 \quad \text{.....[2]}$$

where P_w = moisture percent by weight oven dry basis
W_p = specific weight of soil particles
= Weight of soils solids ÷ Volume of soil solids
= g/cu cm
W_m = specific weight of moist soil
= Weight of soil solids + Weight of soil water ÷ Volume of soil solids + Volume of soil water
= g/cu cm

The equation has three variables. Fig. 2 is a graphic plot of moisture percentage (P_w) against specific weight of moist soil (W_m) using five different values of specific weight of soil particles (W_p). Knowing any two of the three variables, we can find the third variable, e.g., if we are dealing with a soil which has a specific weight of soil particles of 2.64, and we determine the specific weight of moist soil of a sample to be 2.08, the corresponding soil moisture percentage, 19.6, can be read from the graph.

In the same manner, we can determine the specific weight of soil particles if we know the specific weight of moist soil and the moisture percentage.

Two experiments were made to test the usefulness of this method. The first was a paired experiment using the soils oven method and the pycnometer method.

Fifty samples of soil of approximately the same moisture were chosen from a batch of Foard clay loam soil which had a specific weight of soil particles of 2.63 g per cu cm. Each of the 50 samples was run through a soil sample splitter and one-half of the sample was subjected to the soils oven method. The other half was subjected to the pycnometer method. In the pycnometer method, the moisture percentage was calculated (equation [2]) after the specific weight of moist soil was determined.

Fig. 3 shows the forms which were used to calculate the moisture percent by each of the two methods.

The statistical analysis of the data gathered by the paired experiment yielded the following information:

The mean difference of the two methods = 0.152 percent
The standard error of this mean difference = 0.1092
The computed t value = 1.392

The computed t value of 1.392 which compared with a tabulated t of 2.009 for 49 deg of freedom and a probability of 0.05 did not reject the hypothesis that the mean difference was zero.

Upon the basis of this experiment, it is suggested that the pycnometer method can safely be used in preference to the soils oven method. It should be further pointed out that a mean difference of methods as small as 0.15 percent of soil moisture is of little practical importance when the variation of soil moisture from place to place in the field is taken into consideration.

Pycnometer Form

1	2	3	4	5	6	7	8	9	10
Sample number	Weight of bottle + wet soil	Weight of bottle	Weight of bottle + wet soil + water	Weight or volume of water added (4-2)	Volume of bottle	Volume of wet soil (6-5)	Weight of wet soil (2-3)	Specific weight of moist soil (8÷7)	Moisture percent dry wt. basis
1	265.1	196.2	375.8	110.7	141.8	31.1	68.9	2.22	12.8
2	262.6	195.3	374.8	112.2	142.0	29.8	67.3	2.26	11.2
3	267.7	196.2	378.0	110.3	141.8	31.5	71.5	2.27	10.8
4	259.1	195.3	372.8	113.7	142.0	28.3	63.8	2.26	11.2

Soil Moisture Form

1	2	3	4	5	6	7	8	9
Sample number	Can plus wet weight	Can plus dry weight	Can weight	Dry weight	Weight of moisture	Moisture percent (oven)	Moisture percent (sampler)	Difference
1	149.5	141.4	79.5	61.9	8.1	13.1	12.8	0.3
2	151.3	143.8	78.2	65.6	7.5	11.4	11.2	0.2
3	156.0	148.2	79.0	69.2	7.8	11.3	10.8	0.5
4	158.8	150.8	79.4	71.4	8.0	11.2	11.2	0.0

Fig. 3 Forms used in pycnometer tests. (Date, October 2, 1953; soil, irrigation experiment station; $W_p = 2.63$)

The second experiment was run to determine whether these two methods would give the same results over a wider range of soil moisture percentage and on a different soil.

A soil with a specific weight of soil particles of 2.52 g per cu cm was used. Moisture levels of approximately 3, 8, 15, 22, and 35 percent were obtained by the addition of moisture. The analysis of this experiment follows:

TABLE 1. ANALYSIS OF VARIANCE

Source	D. F.	M. S.
Level	4	96,196.58
Method	1	112.13
Level × method	4	49.22
Sampling error	20	34.67

The only items of interest, method, and the interaction of method by level, were not statistically significant. The methods do not appear to differ even at different levels of moisture. There is also an added feeling that the specific weight of the soil particles will not react with the method.

This method would have merit when the moisture of only a small number of samples is to be determined. Approximately 15 min was required for each sample to determine soil moisture by the pycnometer method. After the specific weight of the soil particles has been found, the only equipment needed is a bottle and a set of balances.

Infrared Oven Method

Infrared lights have been used in some commercial moisture testers for grain. A number of tests were run with one of these moisture testers in which soil samples which had been wetted to different amounts of soil moisture were dried. All of the samples of sandy soil reached constant weight by

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Mechanization of Kenaf Fiber Production

Hiram D. Whittemore and Joseph B. Cocke
Assoc. Member ASAE Affiliate ASAE

Agricultural Engineers Develop Machines and Methods for Large-Scale Production

PROGRESS is being made under a research program by the U. S. Department of Agriculture and cooperating agencies toward the development of machines for large-scale production of kenaf fiber in the United States as a substitute for foreign-grown jute. Grown largely in India and Pakistan, jute is widely used in the raw state by industry and, as burlap, by agriculture and industry in the United States. Kenaf is already being grown in India as a substitute for jute and to some extent in Caribbean and Central American countries, including Mexico.

Jute is imported largely from India and Pakistan and averaged 72,719 long tons annually during the 5-year period 1948-1952, inclusive. In addition we import annually about 800,000,000 yards of burlap valued at approximately $90,000,000. Burlap is the country's most valuable textile import and one of our major imports. Except for cotton, jute is more widely used than any other vegetable fiber, and its production in India and Pakistan average 3,415,578,000 pounds annually from 1947 to 1951 which was at least 95 percent of the worlds total.*

Raw jute is required for manufacture of rugs, carpets, furniture webbing and padding, twine and yarns. Jute butts are used for making cotton bale covering and for blending in the manufacture of coarse yarns. Up to three-quarters of our total consumption of burlap is used for agricultural packaging of mill feeds, mixed feeds, flour, and meal, for cotton bagging, sugar sacking, and fertilizer bagging.

Jute is of great strategic importance and dependable source of supply is necessary to the United States and western Europe. Before World War II, India was able to meet the normal demands of the rest of the world for this fiber. Since 1939, however, the supply situation has been uncertain.

In the last few years, however, the price and supply situation has improved. Nevertheless the need for production of jute or a substitute fiber in the Western Hemisphere is a strategic necessity in the event of further world disruptions in shipping and production. The competitive superiority of jute, especially in the agricultural field, has been seriously weakened by developments of the last ten years. Burlap's chief competitor before the war was cotton, but high prices of the latter fiber together with trade preferences for some burlap items have prevented a major change-over from jute to cotton. The significant factor in the packaging and container field has been in the development and use of paper. Shortage of jute during the war and high prices of the war gave strong impetus to technological improvement of the multiwalled paper bag. By 1948, paper comprised 59 percent of total United States consumption of cotton, burlap, and multiwalled paper for bags, compared with 18 percent in 1939. Improved methods of bulk handling and storage have strongly affected the use of all container and packaging materials.

Fibers which may be used as substitutes for jute are the subject of experimentation and development in several areas of the world. India has supplemented her jute crop with mesta, or more commonly known in the western hemisphere as kenaf *(Hibiscus cannabinus)*. Kenaf has been grown in the Caribbean countries and in the United States on limited commercial scales. Mexico has produced small quantities of kenaf fiber as have several Central and South American countries. There are also other countries including Australia, the Philippines and South Africa interested in the production of jute substitutes.

In selecting a fiber plant for production in the United States, and in particular, Florida, several factors had to be considered. A plant adapted to the climate and soil conditions was necessary from an agronomic standpoint, while its adaptation to mechanical production was the principal interest of the engineers who would have to design new machinery and adapt machinery used for other purposes and other fibers. Of the many fiber plants considered, and in many cases still being used for experiments, kenaf best meets the necessary conditions.

Kenaf is the commonly used name for *Hibiscus cannabinus*. Other common names include ambari, bimli jute, deccan hemp, gambo hemp, gombo hemp, and mesta. Kenaf is an annual in the regions where normally grown maturing in 90 to 120 days. It is of upright growth, and when proper planting rates are used, has few branches on the lower portion of the stalk. Stalk height varies from 6 to 12 ft, and in some cases grows to greater heights. A desirable fiber-type growth is around 8 ft, with a stalk diameter of ½ in in thick stands of even height. The fiber is of the bast, or soft type, and is produced in the bark layer surrounding the woody central core. For mechanical preparation and conditioning the most desirable characteristics are the height, stalk diameter, and the lack of lateral branching. In order to make harvesting economical, the total or recoverable fiber percent is important.

The planting of kenaf for fiber production requires no special machinery. Good land preparation and fertilization preceding seeding with a standard grain drill are all that are necessary. Row spacing of 6 to 8 in with seeding rates of 20 to 30 lb per acre gives stands of sufficient density for good fiber yields. Row spacing and seeding rates as well as amounts of fertilizer will vary under different soil and climatic conditions and should be determined by experimentation in areas where the best rates have not been determined. If a good stand is obtained, no weed control will be needed. In order to avoid overmature fiber, the number of acres planted daily should be coordinated with the capacity of the harvesting and defibering machinery.

This paper was presented at a meeting of the Florida Section of the American Society of Agricultural Engineers at Jacksonville, Fla., March 1954. The report is based on cooperative work with Florida Agricultural Experiment Station and the Cotton and Other Fiber Crops Section, Field Crops Research Branch, U. S. Department of Agriculture.

The authors—HIRAM D. WHITTEMORE and JOSEPH B. COCKE—are agricultural engineers, mechanical processing section, agricultural engineering research branch, U.S. Department of Agriculture.

*Foreign Agricultural Service, U.S. Department of Agriculture.

Planting in South Florida can begin in the early spring and proceed to the middle or late summer for fiber production.

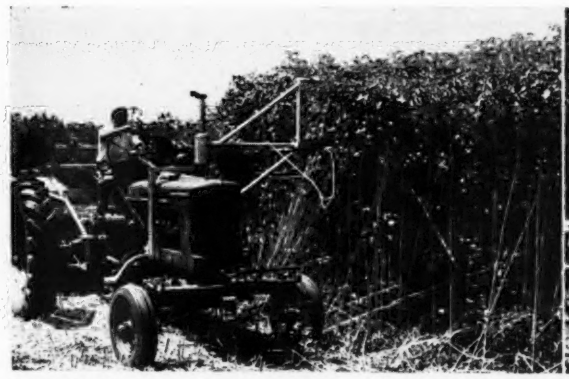
Since kenaf is subject to photoperiodism, plantings for seed production should be made in the late summer or fall of the year, as blossoming and seed production will not start until the day length is less than 12½ hr. The practice of planting for both fiber and seed is not usually satisfactory and not likely to be economical.

Kenaf is usually harvested by one of three methods, namely, cutting by hand, machine cutting, or machine harvesting in combination with some form of field defibering. The hand cutting is used only in areas where labor is cheap and plentiful, and is not practical even under those conditions. This method is usually followed by bundling for tank or pond retting, or decorticating on small semiportable machines in the fields where the fiber is grown. Machine cutting is of two types, the simplest is using a common mowing machine followed by hand collection and bundling. In Mexico, the practice has been reported of gathering the standing stalks into tied bundles and then cutting with a mowing machine.

The war hemp cutter which was a modification of the rice binder has been adapted to the harvesting of kenaf by adding the tying head from the war hemp pick-up binder. A considerable number of hemp cutters and pickup binders built for domestic use in the production of hemp fiber during the war became surplus, and have been adapted to kenaf harvesting. These have been adapted by fitting the tying head from the binder to the cutting machine, thus converting the cutter into a binder. The modified machine cuts and bundles the stalks, leaving the bundles lying more or less in rows in the field, or by use of a bundle gatherer, in piles to facilitate loading for hauling to a central processing plant. As these machines wear out, it is difficult to get new parts and no other machine is being built to replace them. However, the use of combined field harvesting and defibering machines may replace other harvesting methods.

Partial or complete defibering in the field, either separately or combined with harvesting, is desirable from several standpoints. As most of the green stalk weight is eventually discarded, the cost and labor of hauling the entire stalk to another location for further preparation and conditioning is difficult to justify. In addition, these waste products must be disposed of at the central plant and might better be left in the field where they can be returned with benefit to the soil. Machines which make one operation of cutting and defibering are being developed by private and government agencies. They are of two general types, machines which produce ribbons and machines which decorticate or at least partially decorticate. The terms ribboning and decorticating are really degrees of the same thing. By ribboning, we mean removing the woody core which is surrounded by the fiber layer. Some further work is usually accomplished by ribboning. Some bark may be removed as well as separation of the fiber layer into smaller strands. Decortication, on the other hand, implies complete removal of the woody core, the bark, part of the gums and pectins which bind the individual fibers together, and separation of the strands into useable fiber. Various machines do varying degrees of defibering, from simple ribboning to complete decorticating. With kenaf, some further mechanical, chemical or bacteriological processing is required to produce fiber acceptable to the spinners.

Of the several harvesting-defibering machines, only one will be discussed here. This machine, known generally as the USDA ribboner, has been developed over a period of years by the Special Fiber Investigations Project of the U. S. Department of Agriculture in Belle Glade, Florida. It has progressed through several stages from a simple single-drum hand-fed machine used for brushing and cleaning dry fiber and producing ribbons, to a stationary ribboning machine with two drums and a chain feed. During the 1953 harvest season, this machine mounted on tracks and with an extended feed table was used in the field as a ribboner. A tractor with a special cutting and conveying unit was used to pull the ribboner through the field. The harvesting unit, using a modified side-mounted cutterbar mower, gathers the stalks from a 4-ft swath just prior to cutting and conveys the cut stalks to the rear, through a topping saw, and lays them across the feed table of the ribboning unit which follows directly behind the tractor. The conveying system consists of a spring-loaded moving rope acting against a moving chain in a curved track which is so designed that the single-plane curve carries the stalks from the gathering point to the rear and to the far side of the tractor and over the feed table where they are released. The curvature of the track is such that the spring-loaded rope acts against the periphery of the track giving sufficient pressure to hold the stalks. Both the rope and the chain are driven through a gear drive from the tractor. As the stalks move into posi-



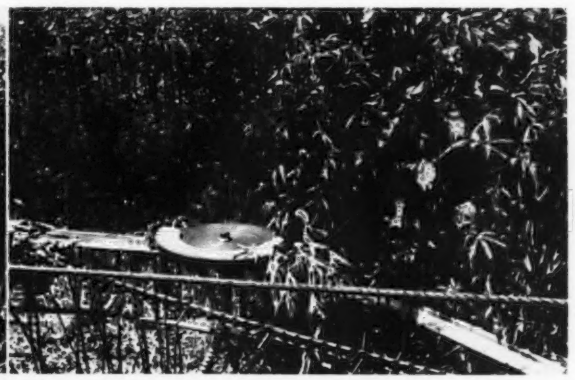


Fig. 1 (*Left*) View of gathering fingers of the USDA ribboner (kenaf fiber harvester) funneling stalks into the throat of the rope-chain conveyor • Fig. 2 *(Right)* This view of the USDA ribboner shows the 16-in ripsaw, driven by a flexible shaft, used to remove the leafy tops of stalks as they are conveyed to the feed table of the ribboner.

tion across the feed table, the butts are lifted by being drawn over the edge of the table and are then in a semi-horizontal position as the tips are released so that they drop into position on the conveying and gripping chains of the ribboning unit.

The ribboning unit consists primarily of two drums rotating in opposite directions and two sets of spring-loaded offset grip chains. As the stalks are dropped on the feed table, they are fed by conveyor chains on the feed table into the first of the two sets of grip chains. These chains grip the middle of the stalks tightly enough to prevent their being pulled out by the action of the drum. As they move back to the rear of the machine, one-half of the stalk length is carried up and over the rotating drum beneath a cover with a fairly close clearance. As the stalks move along the length of the drum, they are acted upon by specially designed serrated bars. When the first half of the stalks is ribboned, the second set of grip chains grips the portion already ribboned and carries the remaining part of the stalks through the second drum. The speed that the drums rotate and the amount and type of material being fed affects the quality of ribbon produced. An even feed from the harvesting unit is therefore necessary.

As the ribbons leave the second drum, they drop into a tying unit which makes two ties about one foot apart. The two ties facilitate handling of the bundle through further processing.

NEW RIBBONER UNDER CONSTRUCTION

At the present time, a new ribboner which will embody the mechanical improvements indicated by field operation last year is under construction. The complete cutting, conveying, and ribboning mechanisms are to be on one frame, which permits the use of any type tractor to be used for pulling purposes only. The gathering mechanism will be hydraulically raised and lowered for varying stalk heights.

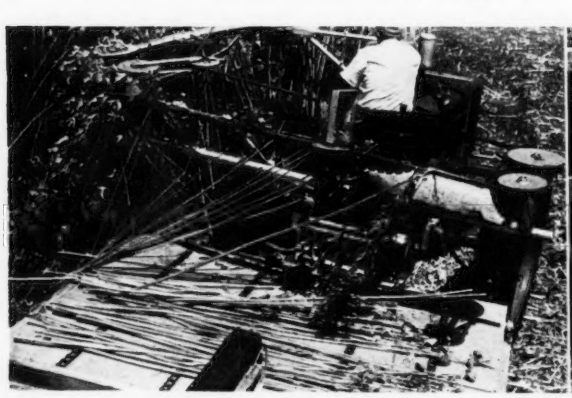
The method used in preparing and conditioning kenaf fiber for sale will depend on what has been done in the field harvesting. If field cutting has produced bundled stalks, either decortication or retting will follow. Small decorticating machines can be used either in temporary locations at the edge of the field or mounted on wheels to be moved from place to place in the field. Usually several of these small machines, of the hand-fed type, are grouped together and driven by a single power source. If moved around in the field, carrying the stalk material to them is handled by a group of laborers, and others are needed for removing the decorticated fiber to the drying area. In this method, the waste material is left fairly well distributed over the field.

A central-station-type plant is generally used when decorticated fiber is to be produced from large acreages. In this case the machinery for decortication, drying, and baling, together with maintenance facilities, storage, loading, and administration buildings are located in one area, preferably near the center of the fields to equalize the hauling distance as much as possible. The decorticating equipment is commonly of the type used for hard fiber production with modification for use on bast fibers. These machines require a hundred or more horsepower for satisfactory operation, and together with other necessary equipment, buildings, and land represent a large investment.

Decorticated kenaf is not generally acceptable to the spinning trade, although several spinners have said that they could spin a satisfactory product from it if necessary by modifying their processes and machinery. However, as long as water-retted fiber equal to imported jute is available at a reasonable price, they prefer to use that. Should the supply of retted fiber be cut off, decortication would probably be the best method to fill a sudden large demand. Several problems need working out to reduce damage and fiber loss, as well as producing a cleaner fiber. Some cleaning or degumming after decortication might be desirable, but adds considerably to the cost of production.

Retting in rivers and ponds is the method used to produce jute and kenaf in India and Pakistan. There the whole stalk is cut by hand, bundled, and submerged in pools of still water. The gummy matter ferments in ten to twenty days, depending on the maturity of the plant and the temperature of the water. When sufficiently retted, the fiber is removed by stripping, followed by washing in the retting pool.

This process can be improved by mechanical handling for producing retted fiber from stalks using tanks having controlled temperature and other conditions. However, the large volume of material that must be handled makes this impractical in the United States and elsewhere in the Western Hemisphere.



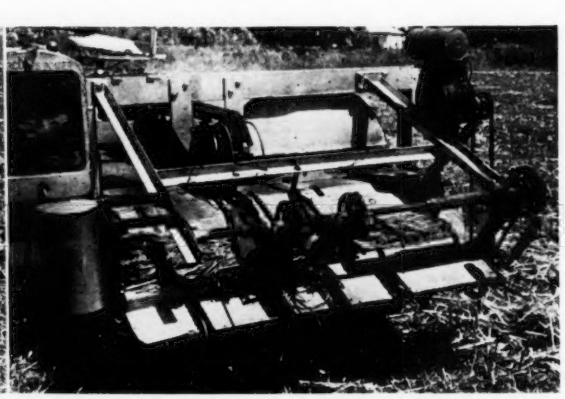


Fig. 3 (*Left*) Stalks are released by rope-chain conveyor as they arrive at proper place on the feed table of the USDA ribboner • Fig. 4 (*Right*) A double-needle tying head receives ribbons and ties them in bundles weighing about 20 lb

A more practical means of water retting can be achieved by use of ribbons which reduce the bulk of material to be handled. This is particularly true where ribbons can be produced in the harvesting process.

Ribbons have several advantages over stalks in that they represent about one-third of the total weight of cut green material. The cost of hauling to central plant processing equipment is greatly reduced and the problem of waste disposal is reduced accordingly. It is possible to decorticate ribbons on large cross-feed decorticating machinery with some increase in capacity. Losses in fiber recovery may be somewhat higher if careful even feeding is not practiced.

For retting purposes, ribbons have the advantages of larger capacity in less tank space, easier handling, reduced retting time, and more even ret. Final cleaning of retted ribbons is simplified by having had the woody core removed in the field so that cleaning is mostly a matter of washing and fiber separation.

A method which reduces the retting time and therefore the tank capacity required, is the use of partial retting together with mechanical cleaning and washing. With controlled temperature, sufficient retting for mechanical cleaning can be accomplished in about three to five days. The ribbons may be loaded in racks for submerging in water or a conveyor can be used. Experimental in-line retting equipment has been designed, though not yet built.

ALTERNATE METHOD OF RETTING KENAF

An alternate method of retting kenaf has been discussed from time to time. It involves drying the ribbons before retting. The advantage would be in spreading the retting process over the entire year if desired, thus reducing the need for large tank capacity. However, retting time is increased by several days and a lower quality of fiber is produced. Such a system would require an extra drying operation as well as greatly increased storage space.

A great deal of time and effort has been spent in attempting to develop a satisfactory chemical cleaning process for decorticated fiber and for ribbons, both in Florida and Cuba. Fiber of good quality has been produced in small quantities by several processes which have proven expensive in all cases. A simple and economical chemical method would have far-reaching effects on fiber production as such a system would be very adaptable to in-line mechanical procedures.

In areas of little rainfall and plentiful labor, drying is usually done in the open air unless the operation is on a large scale which would require unduly large areas for the drying operation. Mechanical or artificial drying is necessary in Florida, Cuba, and where the fiber-harvesting season coincides with the rainy season. Several commercial driers have been adapted to drying long vegetable fibers and are satisfactory if drying capacity is sufficient and temperatures are controlled within safe limits.

The U.S. Department of Agriculture has been experimenting with driers especially designed for drying such fibers as kenaf, ramie, and sansevieria. These driers use a multiple-stage principle having three or more compartments, each having special conditions of temperature and relative humidity at each stage of the drying operation. The wet fiber being fed into the drier can withstand rather high temperature, permitting the heat to penetrate to the center of the fiber cells. As the fiber moves on its conveyor from the heating section into the drying sections, the temperatures are lowered progressively as the humidity is reduced. In the final stages, cooling and tempering takes place.

The fiber moves in a thick layer the length of the drier and is then turned over in being transferred to the lower conveyor to expose the other side of the fiber layer to the hot air being blown down through the conveyor belts.

The air is heated either from steam radiators connected to a boiler or by direct heat from an oil or gas burner. The direct-heat method is perhaps more efficient, and, if necessary precautions are taken, no fire danger is apt to occur.

When the fiber leaves the drier, it is nearly bone dry and is quite brittle, so it must be stored for 24 hr to regain its normal moisture content of 12 to 15 percent. In some cases the storage area is equipped with humidifiers to insure that sufficient moisture is returned before baling.

At the end of the storage period, the moisture is equalized throughout, and the fiber is baled in uniform sized bales of 350 to 500 lb each. Bale densities of 20 to 25 lb per cu ft are generally used. However, no standards have been established for size and density.

There are, therefore, several methods of producing kenaf fiber. Mechanical decortication of stalks can be followed by no treatment, water retting, or chemical retting. Ribbons produced in the field can be water retted, chemically retted, or decorticated followed by water or chemical retting, or no treatment other than the washing received in the machine.

Research at the present time indicates that mechanical ribboning with subsequent water retting will produce a commercially acceptable fiber.

The future of the kenaf industry depends largely on the availability and price of imported fibers of similar type. In times of world disruptions in shipping and trade, the United States and her neighbors in the Caribbean countries could meet the fiber needs for all essential purposes. Against such times, research into growing and the preparation and conditioning of the fiber should continue.

Determining Soil Moisture

(Continued from page 487)

30 min, and all of the samples of clay soil reached constant weight by 45 min.

This method appeared practical, so a full-scale soils oven which could hold 16 sample cans was constructed. Six 250-w infrared lamps were used.

The preliminary work has been on the height of lights above the samples for most uniform heat distribution. Temperature readings were taken by means of thermocouples within samples in the infrared oven and in a conventional oven.

The data to date indicate that soil samples can be dried rapidly in an infrared oven. Samples left in the infrared oven longer than about 30 or 40 min were drier than oven dryness. The future work will include drying different soils to determine the relationship of the moisture percent of samples dried in the infrared oven and the conventional oven.

Low-Pitch Nailed Trussed Rafter

E. George Stern

THE present trend calls for low-pitch roofs with overhang. Such a roof can be supported by trussed rafters spanning the complete width of the house. If such trussed rafters are made of lumber and assembled with nails, they can be site-fabricated or prefabricated without special equipment or tools by anyone familiar with handling lumber and nailing it together.

An effective and efficient design for a 24-ft span, 3-in-12-pitch, nailed trussed rafter with 4-ft overhang is presented in Fig. 1. It was designed for a 35-lb-per-sq-ft roof load and a 10-lb-per-sq-ft ceiling load, if spaced on 2-ft centers.

Using dense-select-structural southern pine of 11 percent moisture content, the assembled trussed rafter weighs approximately 160 lb; thus can easily be erected by a two-man crew.

Loaded at the three panel points with hydraulic jacks, it carried an ultimate test load of 13,200 lb, that is eight times the equivalent design load of 1665 lb, at a maximum total deflection of 4 in of the midpoint of the lower chord. The test load at the allowable deflection of 1/360th of the 24-ft span, that is, at 0.8 in, amounted to 5850 lb, which is 3.5 times the design-load equivalent. At the design-load equivalent, the trussed rafter deflected only 0.12 in.

The observed factors of 8 and 3.5 are ample, since factors of 6 and 2½ to 3, respectively, are considered fully satisfactory. Actually a larger ultimate test load would have been reached, if the splice plates at one of the heel joints would not have failed. Such failure was predicted prior to test performance following visual inspection of lumber and workmanship, since the respective splice plates consisted of the weakest pieces of lumber in the trussed rafter, being fast grown, pitchy, and a borderline case with respect to slope of grain.

Good workmanship in trussed-rafter assembly can eliminate many aggravating and costly deficiencies. Use of proper nails and nailing procedures can result in a permanently rigid structure and can even upgrade low-strength or low-

(Continued on page 495)

This paper was prepared expressly for AGRICULTURAL ENGINEERING and is in sequence of the original paper, entitled "Design of Nailed Trussed Rafters," as published in AGRICULTURAL ENGINEERING (vol. 34, pp. 26-28, January, 1953). It is based on development work performed jointly by the Wood Research Laboratory of Virginia Polytechnic Institute and the Independent Nail and Packing Co., Bridgewater, Mass., manufacturer of the nails used for the trussed-rafter assembly.

The author—E. GEORGE STERN—is research professor of wood construction, Virginia Engineering Experiment Station, Virginia Polytechnic Institute.

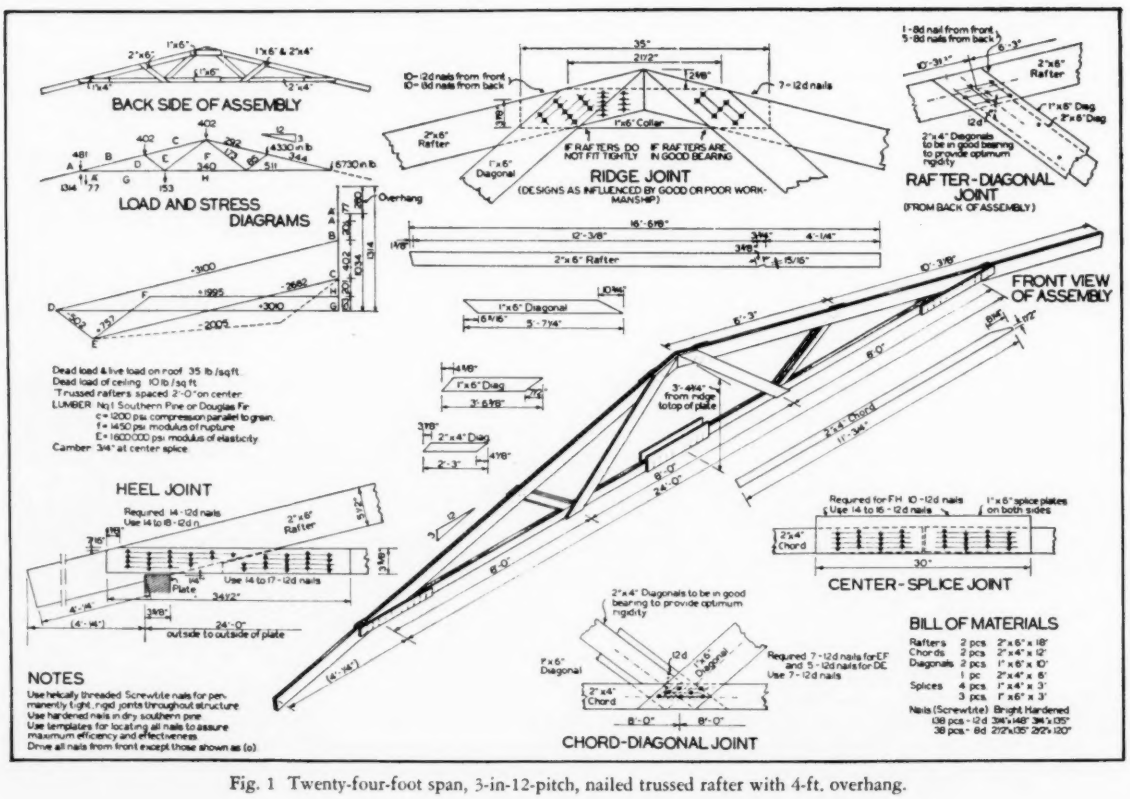

BACK SIDE OF ASSEMBLY
LOAD AND STRESS DIAGRAMS
RIDGE JOINT
(DESIGNS AS INFLUENCED BY GOOD OR POOR WORKMANSHIP)
IF RAFTERS DO NOT FIT TIGHTLY
IF RAFTERS ARE IN GOOD BEARING
RAFTER-DIAGONAL JOINT
(FROM BACK OF ASSEMBLY)
FRONT VIEW OF ASSEMBLY
HEEL JOINT
CENTER-SPLICE JOINT
CHORD-DIAGONAL JOINT
BILL OF MATERIALS
NOTES
Dead load & live load on roof 35 lb/sq ft
Dead load of ceiling 10 lb/sq ft
Trussed rafters spaced 2'-0" on center
LUMBER No.1 Southern Pine or Douglas Fir
Camber 3/4" at center splice

Fig. 1 Twenty-four-foot span, 3-in-12-pitch, nailed trussed rafter with 4-ft. overhang.

Temperature Variations in Stored Frozen Foods

John E. Nicholas and Mark D. Shaw
Fellow ASAE

Results of Studies of Storage Environments of Experimental Frozen Food Products

DURING the past ten years much exploratory work has been carried out with frozen-food storage cabinets. This work has been helpful in designing equipment to provide a minimum variation in temperatures of stored food during experimental periods, and to supply conditions desired in current research projects.

That heat transfer requires a temperature differential is an established physical law of heat flow. The direction of flow is from the higher to the lower level. In a frozen-food cabinet, the evaporator or cooling plate provides the lower level. Thus the air in any cold storage environment is the higher level and its thermal condition is influenced by the evaporating or cooling plate or coil. If there is a change or variation in the temperature of the plate or coil, there is a corresponding though slightly delayed variation in the stored food and air.

Studies of storage environments of experimental frozen foods revealed that temperature of the surrounding air does not represent the temperature of the stored product. A stored product at one location is not at the same temperature as the same product even on the same shelf or in the same horizontal or vertical positions in the same storage cabinet.

Foods Storage Cabinet

A frozen-food storage cabinet of specific design set to operate at a given temperature under the action of a thermostat provides the desired temperature at a given location only periodically. Temperatures will vary above and below the set point with time because of cycling of the refrigeration unit. Theoretically, there are as many different temperatures in a given environment as there are points of measurement.

For any selected food-storage temperature, the storage cabinet is under the control of a thermostat, the cooling unit cycling between certain temperature limits. For any given cabinet design, temperature variations depend upon the *(a)* sensitivity of thermostat and the location of its sensitive element, *(b)* the effectiveness of insulation and amount of heat leakage, and *(c)* the percent and distribution of load in the cabinet.

Experimental Studies

Preliminary studies disclosed need for improvement in design of commercial frozen-food storage cabinets to meet experimental conditions. It was determined that vertical types with no less than 6 in of insulation on all walls and doors would meet the requirements satisfactorily if external or ambient air temperatures could be maintained at similar low and relatively uniform levels.

Early trials showed that such cabinets placed in a room maintained at an air temperature of approximately 24 F might meet the requirements satisfactorily. The 24 F room (Fig. 1) was especially designed for this purpose.

The room subsequently constructed is large enough to accommodate at least five 30-cu-ft vertical cabinets. Its height permits six symmetrically spaced 8-ft evaporator plates to be hung from the ceiling. Two 1½-hp, air-cooled F-12 compressors provide the required refrigeration. Electric interconnections permit either or both compressors to operate continuously or to cycle under the control of the thermostat. Since the evaporators are equally spaced over the ceiling, no fans are required to prevent air stratification. The air movement by gravity has been found sufficient to maintain the minimum possible variation of temperature within the room.

Experimental Procedure

The 24 F room has been in continuous use and operation since June, 1948. Plans were made to hold all experimental foods stored for quality studies at three temperatures: 10, 0, and —20 F. No stored product was held longer than one year, but the experimental foods have been held in these cabinets for five consecutive years. A 30-cu-ft vertical storage cabinet housed in the 24 F room was set to cycle at each of these proposed temperatures.

The 24 F room was purposely designed to provide a relatively uniform external temperature for the storage cabinets. This also served to reduce the large temperature difference that might prevail particularly with the —20 F storage cabinet if the outside air reached a room temperature of 80 F or more during warm summer months. Hence, for the coldest storage cabinet with —20 F internal and 24 F external temperatures, the differential would be 44 degrees. This should, at least theoretically, reduce the internal temperature differential during cycling between the evaporator plates and the stored frozen products and also between the plates and the internal air. Subsequent evidence proved the soundness of the design.

The experimental frozen stored foods were packaged for convenience of sampling. The meat samples weighed 30 to 80 g each and were wrapped in aluminum foil. The vegetables were packed in uniform plastic containers. The quantity of product in each container varied from 200 to 350 g depending on the bulkiness of the food.

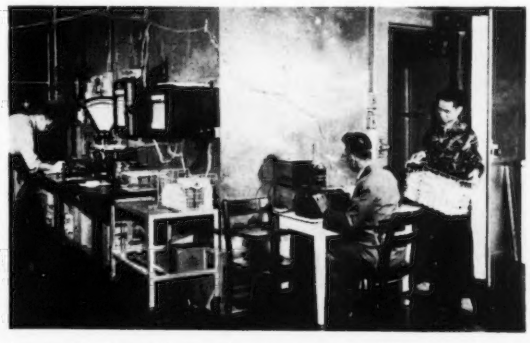


Fig. 1 The 24-deg F room housing the vertical frozen-food storage cabinets. It is built with aluminum insulation. The internal dimensions are 16 ft 2 in by 12 ft 5 in and 8 ft 3 in high

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The authors—JOHN E. NICHOLAS and MARK D. SHAW—are, respectively, professor of agricultural engineering and senior student in the agricultural engineering department, The Pennsylvania State University.

Each storage cabinet contained at any given instant the same kind and the same amount of stored frozen product. When monthly samples are removed for quality analysis, an equivalent number of packages, filled with water, should be placed in each cabinet to maintain comparable loads. Change in load affects cycling and allows different internal air and food temperature patterns.

To reduce variability in the records caused by uneven distribution of individual particles within containers used for temperature measurements, an equivalent quantity of water was used as a substitute load. This permitted a uniform mass and provided ease in the location of thermocouples during storage periods and cycling.

Recording was done by two 16-point automatically operated potentiometers. The thermocouples on one were made with No. 24 iron constantan wires. This recorded a temperature nearly every 58 sec requiring approximately 15.5 min per cycle, for the 16 points. Fig. 2 was obtained from this recorder. Thermocouples on the second recorder were made with No. 30 copper constantan wires. This instrument recorded a temperature every 15 sec requiring 4 min per cycle for the 16 points. Figs. 3 and 4 were obtained from this recorder.

Since any experimentally recorded data depends on the accuracy of the recording instrument, thermocouple 16 was located in a thermos bottle filled with crushed ice. This served as a guide and gave assurance that accuracy of the recorded temperatures at all other points was dependable.

Fig. 2 illustrates two views of a storage cabinet and the symmetrically located 12 packages, the temperatures of which were recorded. Thermocouples 1 to 12, inclusive, measured frozen product (water) temperatures. Couples 13, 14 and 15 located at center of the top, second and bottom compartments measured air temperatures.

Fig. 2 represents a 5-hr period taken at random from a 24-hr record made on April 13 for the 10 F cabinet.

The highest mean temperature, recorded by couple 12, was 13.3 F, and the lowest, recorded by couple 3, was 9.42 F giving a mean for the cabinet from 12 measured points of 11.7 F.

Figs. 3 and 4 show the corresponding temperatures of the stored products in the 0 and −20 F cabinets taken from random 5-hr samples of a 24-hr record made on April 22 and 29, respectively.

All temperatures recorded in Figs. 2, 3 and 4 were taken under similar conditions, but at different times. No record was made earlier than 48 hr after a cabinet door was opened for loading or sample removal. In each cabinet there is also a portable continuously recording temperature instrument, using a weekly chart and located at symmetrical points for each cabinet. These serve to check the performance of the cabinets for their respective temperature settings.

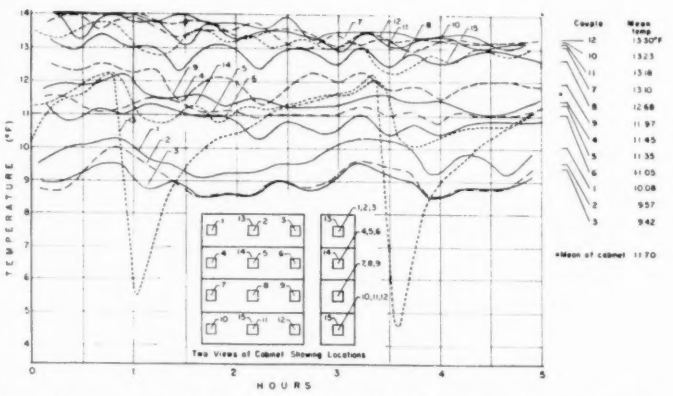


Fig. 2 Temperature variation and cycling in the 10 F storage cabinet. Two views, front and side, showing the location of the packages in which temperatures were taken in the four compartments. Couples 1 to 12 recorded temperatures of 400 g of water during a 5-hr period and 2 complete cycles. Couples 13, 14 and 15 showed air temperatures at center of top, second and bottom compartments, respectively, for the same period as couples 1 to 12

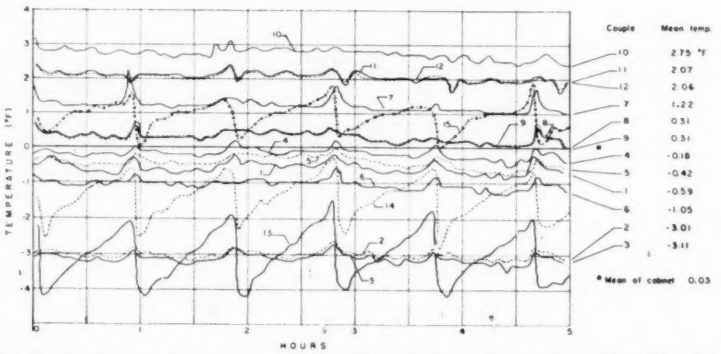


Fig. 3 Temperature variation and cycling in the 0 F storage cabinet. Location of packages for temperature records, similar to Fig. 2. The mean temperature, based on 12 different couples over a 5-hr period and 5 complete cycles, was 0.03 deg. The highest mean temperature 2.75 F was recorded by couple 10, and the lowest, −3.11 F, was recorded by couple 3

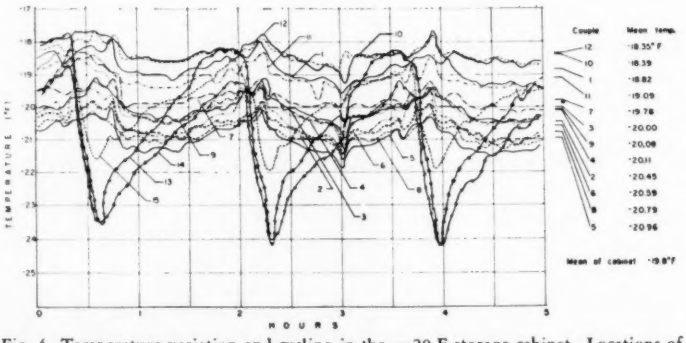


Fig. 4 Temperature variation and cycling in the −20 F storage cabinet. Locations of all couples were similar to Fig. 2. Warmest point, couple 12 with −18.35 F mean. Coldest point, couple 5 with −20.96 F mean. The mean of the cabinet was −19.8 F

For convenience of comparison Table 1 gives summary data on running and idling time for the cabinets at the respective internal temperatures when operating in the 24-deg room.

TABLE 1. Summary of cabinet performance based on a 24-hr period for the respective temperature setting, showing the number of times each runs and idles and the duration of each running and idling period in minutes, and the percent of running time

Cabinet No.	1	2	3
Proposed temperature, F	10	0	−20
Mean temperature obtained, F	11.7	0.03	−19.8
Mean cycles per day	8	27	13
Mean running time per cycle, min	6.8	2.9	19.9
Total running per day, min	51.0	78.0	259.0
Mean idling time per cycle, min	169.0	51.0	94.0
Percent running time	3.9	5.4	17.5

DISCUSSION

When frozen-food storage temperatures are reported or discussed, the general inference is, as might be expected, that constant temperatures exist in a frozen-food storage cabinet. That this is not the case, even under very favorable conditions, is evident from the data presented here. These variations of temperature are much less than exist* under usual conditions of food storage.

If, as in precise experimental work, more definite information is needed on the actual temperature pattern of a stored product, individual measurements at specific points are necessary.

SUMMARY

1 This reports actual storage temperatures of frozen products at proposed temperatures of 10, 0 and −20 F.

2 Three 30-cu-ft storage cabinets, all of vertical type and of same design, provided the necessary storage environments.

3 A 24-deg room, thermostatically controlled, especially designed, housed the storage cabinets.

4 All temperatures recorded for each storage condition represent symmetrically placed packages.

5 The period of recorded temperatures for each cabinet is for a 5-hr duration, taken at random from a 24-hr continuously recorded interval.

6 Figs. 2, 3 and 4 are transcribed from a recorded chart, for a 5-hr period from a 24-hr continuous record, but taken on different days.

7 The mean temperatures obtained for the 3 cabinets from the 12 points measured were 11.7, 0.03 and −19.8 F.

8 Figs. 2, 3 and 4 represent variations in temperatures of stored frozen products, based on water-equivalent loads.

9 The largest variation during cycling in each cabinet is shown by the air thermocouples 12, 13 and 14.

10 The symmetry of air temperature curve shows that air follows closely the variation of the evaporator plates for each cycle.

*Freezing rates of foods and storage temperatures in vertical cabinets, Pennsylvania Agricultural Experiment Station Bulletin 572.

Nailed Trussed Rafter

(Continued from page 492)

quality lumber to some extent.

A trussed rafter is most effective when the lumber is tightly fastened at the joints. Since the load at each joint is a shear load, the structure may fail if tight joints are not maintained. Such tight joints can be assembled even under adverse conditions by use of properly threaded nails. Their large withdrawal resistance opposes joint separation, even when the lumber has a tendency to warp.

If such properly threaded nails are used, they may be driven from one side of the trussed rafter into the three-member joints. The nails will be loaded in double shear and the joint can be designed on this basis. The threads along the nail shank provide sufficient withdrawal resistance to eliminate any opening of the joints during service. In contrast to this, plain-shank nails or poorly threaded nails allow the nailed lumber to slide toward the nail point, which results in open joints and possible structural failure. Hence nailing from one side, which is desirable from the assembly viewpoint, should be permissible only if properly threaded nails are specified and used.

HELICALLY THREADED NAILS RECOMMENDED

For maximum joint rigidity, the use of helically threaded steel nails is recommended. These nails "screw" into the lumber during driving, thus forming helical threads in the wood. This results in maximum rigidity of the nail in the wood and in minimum joint deformation during loading and during the service life of the trussed rafter.

For ease in driving the required number of nails into relatively hard softwood, such as dry southern pine and Douglas fir, without pre-drilling it, the use of the slender, but stiff, hardened-steel, helically threaded nail is recommended. It can be driven faster than the common nail without bending or buckling. It decreases splitting of lumber and therefore makes the joint more effective.

Proper nail spacing with respect to end and edge distances, and sufficient spacing between nails along and across the grain, are important with respect to the effectiveness of nailed joints. It is possible to locate more nails in a joint by choosing an effective nailing pattern than by random nailing. If the design shows both the minimum number of nails required for the joint and also the maximum number which can be used effectively, the carpenter can adjust the number and location of the nails in a joint to any given conditions presented by the lumber in the field.

If nailing templates are used for all joints, satisfactory nail spacing can be assured. The holes in these templates are somewhat larger than the nail heads so that, after the nails are driven, the templates can be removed and reused. Templates can be made of cardboard or stamped out of metal, depending on the number of expected reuses. The use of nailing templates is a time-saving feature. Hence their use is economical even if only a small number of trussed rafters is to be built at a time.

The use of a proper nailing jig, to assure a quick, uniform, and tight line-up of the lumber for all trussed rafters, also helps to eliminate wavy roofs and ridge lines of the sort which have been criticized justifiably, since they are generally caused by poor workmanship and since they could easily have been avoided if a nailing jig had been provided.

Determination of Water Flow from Gated Pipe

Vaughn E. Hansen

THERE is urgent need for inexpensive and yet accurate methods of measuring and distributing water for irrigation purposes. One of the newly developed methods for distributing water is gated pipe. This paper deals with a practical method of measuring and controlling the flow from gated pipe.

The first step in this development was to design a simple and yet effective tool for adjusting the gates to the desired opening. The improved tool reported herein will be found to be far more practical for gate adjustment than the conventional S shaped tool. The second aspect was to install an inexpensive pressure connection to the pipe; and the third to determine the flow resulting from a given pressure and gate opening. Conditions at the location where the gated pipe is to be used may dictate an individual calibration but the principles reported herein can be applied to good advantage. The result will be an inexpensive and yet accurate method of measuring the flow from gated pipe.

On the Greenville Farm at North Logan, Utah, an extensive regional experiment is being conducted in which it is necessary to apply water accurately and carefully to 80 furrow plots and 80 sprinkle plots. On the 80 furrow plots the water is being distributed by 40 sets of gated pipe which would require from 15 to 20 measuring devices of the conventional type to measure the flow accurately. Not only is the cost of this number of conventional devices prohibitive to the project, but also the moving of the measuring devices from one plot to another is also prohibitive under the necessary field operation. Consequently the need was urgent for the development of an accurate, inexpensive, and yet convenient method of controlling and measuring the water onto the plots.

This paper was prepared expressly for AGRICULTURAL ENGINEERING. Developed under the Research and Marketing Act, Project W-9, the eleven western states and Hawaii cooperating with the Utah Agricultural Experiment Station, the soils division of the Bureau of Plant Industry, Soils and Agricultural Engineering and the irrigation division (Research), of the Soil Conservation Service, U.S. Department of Agriculture.

The author—VAUGHN E. HANSEN—is irrigation engineer, U.S. Department of Agriculture, and research associate professor, Utah Agricultural Experiment Station.

Acknouledgment. The author expresses his appreciation to Stuart Meerscheidt for his help in the initial laboratory studies and to Jay Bagley who conducted the later laboratory and field investigations.

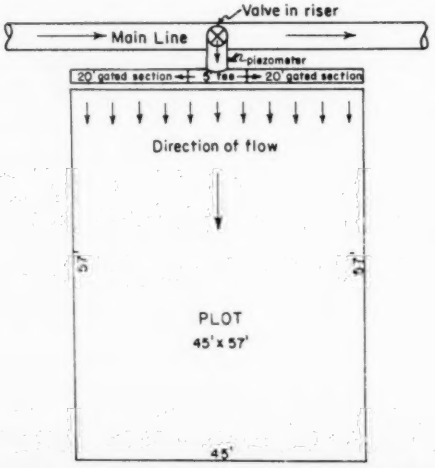


Fig. 1 Schematic plan view of irrigation system on an experimental plot

METHODS OF CALIBRATING

The dimensions of each plot irrigated by use of gated pipe are approximately 45 ft by 57 ft. The distribution system consisted of one T section 5 ft long with two 20-ft lengths of 4-in gated pipe attached to each end of the T. A typical plot layout is shown in Fig. 1.

For the purpose of measuring the piezometric head, a standard piezometric connection was made to the pipe, consisting of copper tubing soldered to the sidewall of the T section about 3 in ahead of the T. In this position, the tap was protected from breakage or damage resulting from ordinary field use. Furthermore, this location gave a characteristic measure of the piezometric head as the flow entered the 4-in gated pipe. To the copper tubing a short length of rubber tubing was attached, on the other end of which was a length of glass tubing. The piezometric head was measured above the center line of the gated section of pipe. An easily manufactured sheet-metal clamp attached to a wire stand held a plastic scale which indicated the piezometric head at the tap connection. The plastic scale had bands painted on its surface indicating the head required at given gate openings to produce the desired flow onto the plot. The piezometer tap and gage are shown in Fig. 2.

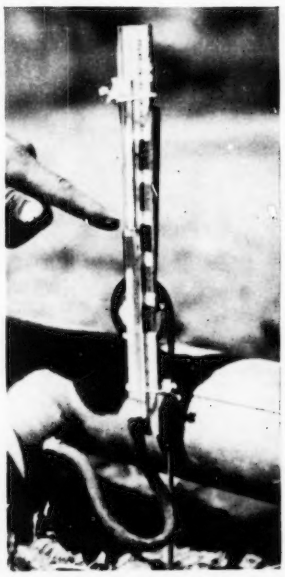


Fig. 2 Method of measuring piezometric head

It was difficult to get an

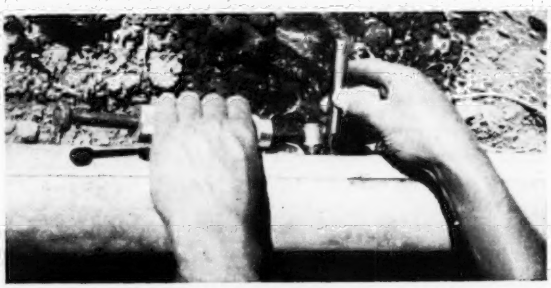


Fig. 3 Use of improved gate-closing tool with the sliding handle and the gate-opening gage

accurate setting of the individual gates by use of the conventional gate closing tool which consisted essentially of a piece of ⅜ or ½-in rod bent into an S shape. Since the accuracy of the entire method of measurement is dependent to a considerable degree on the accuracy of the gate opening, the improved gate closing tool shown in Fig. 3 was developed. Such a tool was easily manufactured and effective in obtaining the necessary gate opening. The gate opening was determined by the use of a half-round gage inserted into the gate. The gate was then opened or closed until the scale was perpendicular to the center line of the pipe. This procedure, using the improved gate-closing tool together with the gage, was found to be entirely satisfactory. Since the gates must be adjusted for any given irrigation, it takes only slightly more time to adjust them to a given setting. Such a setting not only insures an accurate measurement of the flow, but also makes possible a uniform setting of all the gates.

As the flow moves down the gated pipe, the friction losses reduce the available energy, so that the discharge from a given opening tends to be reduced. However, the discharging flow has the opposite effect by reducing the velocity, thus causing an increase in pressure in the line as indicated by the Bernoulli relationship. An analytical solution of a manifold problem of this type is complex; however, laboratory tests readily indicated that within the range of the discharge used, the flow from each gate would be equal when the pipe was set at a slope of 1 in 300. Consequently for the arrangement of the gated pipe as shown in Fig. 1, each section of the pipe attached to the end of the T was placed on a slope of 1 in 300.

The erosion problem caused by the jets was aggravated by the above procedure, since part of the pipe was above the ground surface. However, a practical solution to the difficulty was found by placing a section of old burlap sack in the furrow where the jet would strike the soil. This reduced to a minimum the erosion tendency of the jets and yet allowed the pipe to be elevated where needed.

Results

By placing the sections of the gated pipe on a slope of 1 in 300 and measuring the piezometric head above the center line of the gated pipe, the discharge was determined for given gate openings. The curves for gate spacings of 22 and 36 in are shown in Figs. 4 and 5 from which the discharge can be determined with an accuracy within 2 percent.

General Application

It should be noted that the above procedure applies to a specific arrangement of gated pipe. However, for any given application, the same principles can be used to determine the discharge-opening-head relationship. Furthermore, these determinations can be made in the field with an accuracy within from 2 to 5 percent depending upon the accuracy of the gate setting and the method of calibrating.

CONCLUSIONS

1 The proposed method of measuring the discharge from gated pipe is not only inexpensive but also convenient and practical.

2 An accuracy within 2 percent can be obtained with reasonable care in the setting of the gates and calibrating of the pipe.

3 By the use of the improved gate-adjusting tool, the gates can be accurately set to a given opening with a minimum of effort and inconvenience on the part of the operator.

4 The proposed method automatically insures an even distribution of water into each furrow from each outlet.

5 Even though an individual calibration may be necessary for the intended application, this calibration can be made conveniently and accurately with a minimum of equipment.

6 Any erosion resulting from the jets issuing from the gate openings can be inexpensively and satisfactorily controlled by the use of a piece of burlap sack placed in the furrow where the jet strikes the ground.

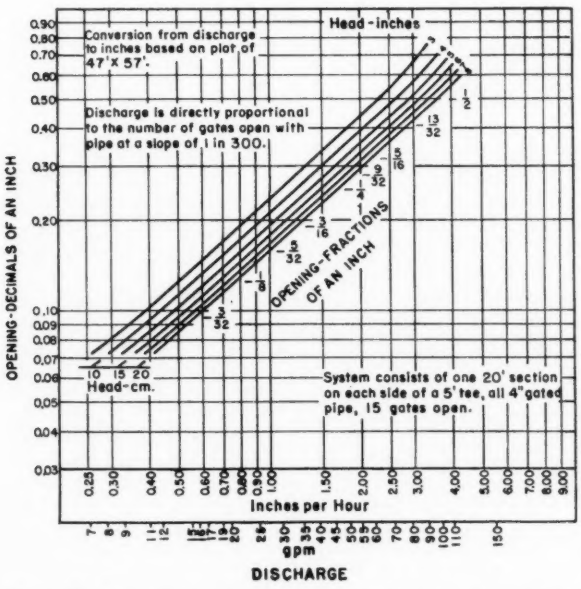

Conversion from discharge to inches based on plot of 47' x 57'.
Head - inches
Discharge is directly proportional to the number of gates open with pipe at a slope of 1 in 300.
OPENING-FRACTIONS OF AN INCH
OPENING-DECIMALS OF AN INCH
Head - cm.
System consists of one 20' section on each side of a 5' tee, all 4" gated pipe, 15 gates open.
Inches per Hour
gpm
DISCHARGE

Fig. 4 Discharge-opening-head relationship for a 22-in gate spacing

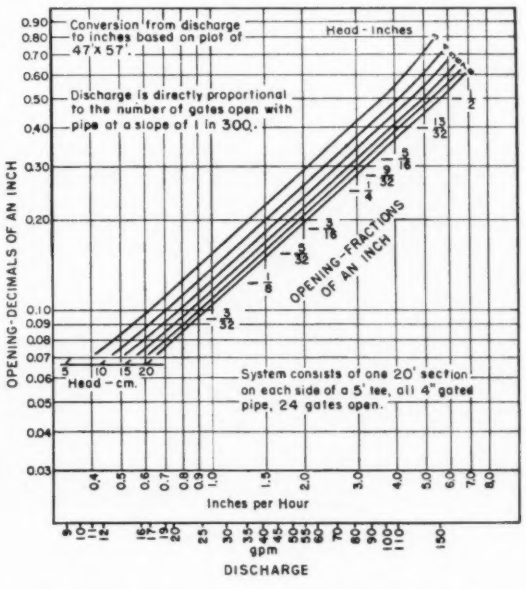

Conversion from discharge to inches based on plot of 47' x 57'.
Head - inches
Discharge is directly proportional to the number of gates open with pipe at a slope of 1 in 300.
OPENING-FRACTIONS OF AN INCH
OPENING-DECIMALS OF AN INCH
Head - cm.
System consists of one 20' section on each side of a 5' tee, all 4" gated pipe, 24 gates open.
Inches per Hour
gpm
DISCHARGE

Fig. 5 Discharge-opening-head relationship for a 36-in gate spacing

Sprayers for Experimental Plots

Glen E. Page
Member ASAE

THE success of 2, 4-D as a weed killer has caused great interest in the use of chemicals for the control of undesirable plants. Thousands of experimental plots are sprayed every year with this and other chemicals. New chemicals are constantly being developed and need to be screened in the greenhouse under controlled condition, with the chemicals showing promise further tested in the field. Special equipment for applying sprays in the greenhouse and on small plots is required to help insure reproducible results. It is absolutely essential that this equipment spray at a constant pressure and at a constant speed for an entire plot or replication of plots. To meet these needs, a sprayer for use in the greenhouse and a small field plot sprayer was developed at Oregon State College. These two sprayers are discussed separately in this article.

The Greenhouse Sprayer Booth

Other important requirements of the greenhouse sprayer were as follows:

1 The equipment should be easily cleaned and require a minimum of time in changing from one chemical to another.
2 One man should be able to take care of all operations without help.
3 Drift of spray mist should be held to a minimum.
4 The equipment should be reasonably portable with over-all dimensions held to a minimum.

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The author—GLEN E. PAGE—is assistant agricultural engineer, Oregon State College.

Acknowledgment: The sprayers described in this paper were developed for the departments of farm crops and agricultural chemistry, Oregon Agricultural College. Special acknowledgment should go to Dr. V. H. Freed, associate chemist, and to W. R. Furtick and E. R. Laning, research assistants in farm crops and horticulture, for setting up the requirements for the experimental sprayers and suggesting changes.

To simulate field-spraying conditions, two methods are available in the greenhouse:

1 A standard weed-spraying nozzle passing at a constant velocity and affixed height over stationary plants
2 Potted plants passing at a constant velocity under a fixed spray nozzle.

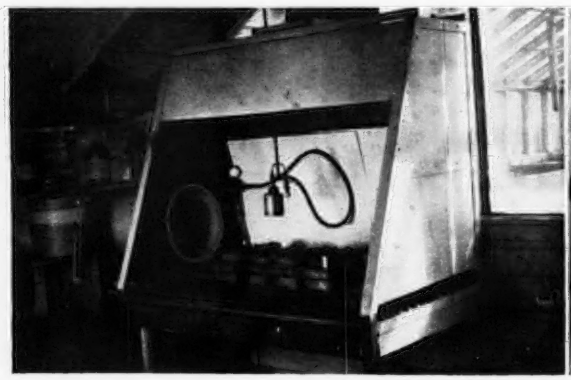
The traveling nozzle over stationary plants was selected because it could easily be operated by one man; it had simplicity of design, required a small amount of space, and could be easily cleaned.

An over-all view of the greenhouse sprayer is shown in Fig. 1. The complete sprayer is 4 ft 4 in wide, 2 ft 8 in deep, and 5 ft 9 in tall. The equipment was designed so it would go through a standard 3-ft door. The main frame is made of $1\frac{1}{2}$ x 3/16-in angle iron. The spraying car used $\frac{1}{2}$ x $1\frac{1}{4}$ in stock for rails.

The car is powered by a 1/50 hp, reversible capacitor, 14.4-rpm Bodine gear-reduction motor. The drive consists of a 3/32-in airplane control cable wrapped once around the motor pulley, the ends of the cable being secured to the ends of the main frame. A step cone pulley allows the speed to be quickly changed from one fixed speed to another. In operation, the plants in flats or pots are set on a table-height, $25\frac{1}{2}$ x 47-in removable grill for spraying. The grill allows any excess spray material to pass through into a catch pan immediately below. Three sides and the top of the spray booth are completely enclosed to confine any spray mist. An exhaust fan duct on the left removes any spray mist from the house.

Source of Pressure and Spray Supply

The equipment was originally designed for the use of an air-atomizing siphon nozzle, but due to the nozzle producing a different type spray deposit than the farm sprayers, as well as excessive fogging, it was changed to using regular Spraying Systems TeeJet nozzles. The spray material



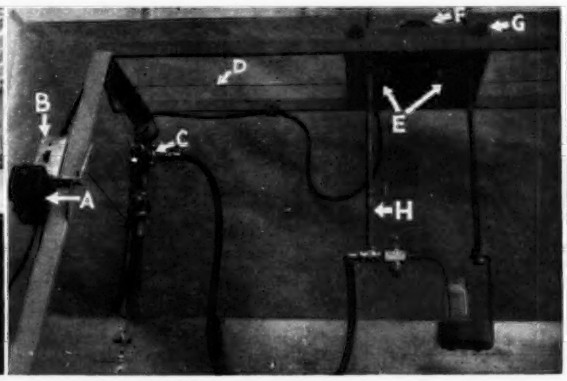


Fig. 1 *(Left)* The spraying booth at Oregon State College for applying experimental herbicides for study under greenhouse conditions. The exhaust duct to the left of the booth removes any spray-laden air from the greenhouse. A pressure oil can is used for the spray tank • Fig. 2 *(Right)* The spray car, rails, and controls: A car motor reversing switch; B, compressor switch; C, air-pressure regulator and pressure gage; D, traction cable; E, cable guide wheels; E, car motor and drive pulley; G, car wheels; H, support for spray head. The air atomizing nozzle has been replaced with standard weed nozzle in Fig. 1

container is from a Plew's pressure oiler. A diaphragm-type compressor furnishes air at 40 lb per sq in. Pressure regulators in the line allow for spraying at any desired pressure below 40 lb. The oil cans used for spray containers come in several sizes and can be easily changed.

Controls

The controls consist of the air compressor switch and the motor reversing switch, easily accessible for operation by the left hand. The rates of application can be controlled by changing nozzle tips, air pressure, and the size of the pulley used in contact with the cable.

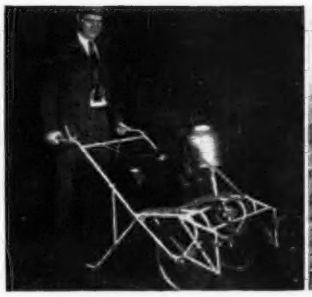


Fig. 3 *(Left)* The author at the controls of plot sprayer with gasoline-engine-driven gear pump. By-pass from pump furnishes agitation for unstable emulsions • Fig. 4 *(Right)* War-surplus oxygen bottle supplies air for the Hudson simplex compression sprayer. The air-pressure regulator valve between air bottle and tank insures constant pressure for spraying. Quick couplers on both air and liquid lines make removal of spray tank for cleaning easy. The tractor speedometer affords easy check on ground speed and distance

The Push-Type Field Plots Sprayer

The push cart on which the plot sprayers are mounted is designed so that it can be quickly changed from a sprayer using a compressed-air tank to furnish pressure for spraying to a sprayer using gasoline engine and gear pump to furnish pressure for spraying and for agitation. We have found in the past that the compressed-air sprayers have not given sufficient agitation to keep some of the powders in suspension; thus we do not get a uniform deposit at the beginning and end of a spray trial. The gasoline engine and gear pump will be only used on plots requiring considerable agitation of the spray material.

The over-all width of the sprayer, not including the boom, is held to under 30 in. This is to enable the sprayer to be used between rows of nursery stock and small fruits, such as raspberries, for the application of placement sprays at the base of the plant. The over-all dimensions of the sprayer are also held to a minimum so as to take a minimum of space in the pickup truck used by the research workers for carrying the herbicide equipment. It is also necessary to carry in the pickup an air compressor, chemicals, and the supply of water for rinsing the machine between trials.

An assortment of booms were made for use in the different types of studies. The height of the boom is controlled by a parallelogram arrangement as shown in Figs. 3 and 4. The height of the boom can be quickly adjusted for any desired height of spraying. To keep the sprayer from tipping over when not being used, a rear support hinges down and locks in position.

Rate of application is determined by speed of travel, liquid pressure, size and spacing of nozzles.

EDITOR'S NOTE: Working drawings of the experimental sprayers described in this paper are available, as follows: Plan 3151-1, six sheets, Portable Plot Sprayers, $1.85; Plan 3151-2, four sheets, Greenhouse Sprayer, $1.35. Address Agricultural Engineering Dept., Oregon State College, Corvallis.

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Machine Processes Corncobs

(Continued from page 473)

crusher. The crusher was tested to determine its power requirement, capacity and size of particles delivered at various settings of the machine. It was found that 11.12 tons per hour of cobs could be crushed at a power requirement of 20.55 hp, or a rate of 1.85-hp-hr per ton, when the crushing rollers were spaced ¾ in apart. At this setting, 86.5 percent of the particles passed a 1-mesh screen, 7.2 percent passed a 2-mesh screen, and 0.9 percent passed a 4-mesh screen.

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Human Factors in Engineering

WE THINK conventionally of technical societies as existing primarily as a focal gathering point for those having a community of interest in a technology and for the dissemination of information with respect to that interest. Considering that such a group is in itself a segment of society and thus is made up in its membership of men and women with singleness of purpose, I would broaden the objectives of a technical society to include the techniques of better human relations.

Engineering educators are conventionally and properly thought of as learned folks shouldering the heavy responsibility of shaping young minds and instilling in their students the maximum of fundamental technical knowledge. I would like to lay down the challenge that engineering educators have the priceless opportunity of also helping the engineering student to shore up the crucible in which that knowledge is contained. Knowledge to be useful must be in the mind of a person of sound character or that knowledge might some day be wasted or misused.—J. J. Cronin in *Journal of Engineering Education* for May, 1954.

Combining Corn

Geo. E. Pickard and H. P. Bateman
Member ASAE Member ASAE

A STUDY of the adaptation of the combine to harvesting corn was begun by agricultural engineers at the University of Illinois in the harvest of 1950. The first three seasons were devoted to an evaluation of the rasp-bar cylinder as a corn husker and sheller.

Objectives for 1953

The objectives of the work of 1953 were threefold. The principal aim was to be able to draw some conclusions on the problem of getting the corn plant into the combine since a regular reel will not handle tall corn nor lift lodged stalks. This season's work was based on the principle of taking the whole plant into the combine in order to avoid a snapping operation and to permit use of a shredder on the back of the combine if so desired.

The second objective was to study the problem of separation of the corn from the stover, and the third aim was to evaluate the cylinder and separating capacity required to handle a heavy stand of corn.

Preparation of the Combine

For this work a 6-ft straight-through-type combine was used. The feeding device is shown in Fig. 1. This attachment, which is similar to one developed by a machinery manufacturer in early experiments in corn combining, consists essentially of a pair of inclined, counter-rotating augers with floating snouts and sheet metal shields. The role of the augers is to swing lodged corn stalks back onto the feeder and to push standing stalks back toward the feeder before they are cut off. They are intended to perform the same operations as pickup fingers and the reel in combining small grains. For this experimental work the augers were ground-driven and the attachment was limited to one row.

In order to facilitate movement of stalks through the cylinder, the rear extension and fingers of the concave were lowered so that the stalks did not have to turn such a sharp corner below the beater.

The spout of the return elevator was relocated to deposit the returns behind the cylinder since no reshelling was necessary.

Field Trials, Machine Changes, and Results

As first built, there was space of about 2 in between the flights of the two augers. It was found that cornstalks in this space often fell forward after being cut off. The diameter of the augers over the middle third of their length was increased as shown in Fig. 2, so that the flights almost touched. With this arrangement the stalks were under control before being cut off and were forcibly pushed back onto the feeder. It is believed that this larger diameter should have been continued to the top of the augers.

Some difficulty was encountered with jamming at the top of the augers. This developed from a single stalk being caught against the bearing mount at that point. Blocks were added, as shown, to increase the effective diameter of the auger shaft so that the stalks could not get in against the bearing mount. Most clogging difficulty was eliminated in this way, and it is concluded that larger diameter flighting at this point would have been still more effective.

The major difficulty was caused by the tops of the tall cornstalks falling on the cover over the cylinder and the forward beater. They thus bridged over the feeder canvas which could not get hold of them.

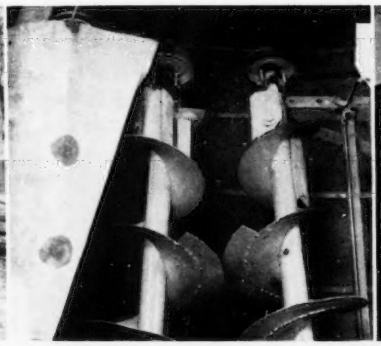
The cover over the beater in front of the cylinder was removed in the hope that the beater would knock the stalks down onto the feeder. There was no appreciable improvement. No improvement was noted when the serrated, spiraled fins shown in Fig. 3 were added.

Several rows of corn were topped at a height of 6 ft so that the stalks would fall onto the feeder canvas ahead of the beater. Feeding was much more even but still not satisfactory since the wooden slats on the canvas do not engage the slippery stalks effectively.

(Continued on page 504)

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Minneapolis, Minn., June, 1954, as a contribution of the Power and Machinery Division.

The authors—GEO. E. PICKARD and H. P. BATEMAN—are, respectively, professor of power and machinery and research associate in agricultural engineering, University of Illinois.



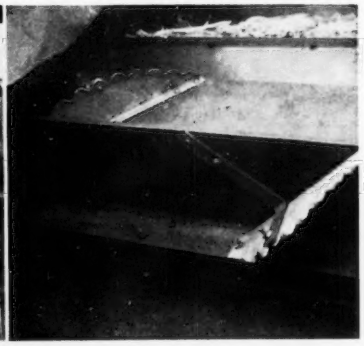
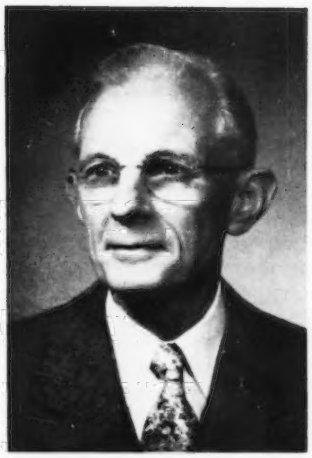


Fig. 1 *(Left)* Combine with ground-driven attachment for harvesting corn • Fig. 2 *(Center)* Auger-flight diameter was increased and blocks were added to improve feeding • Fig. 3 *(Right)* Serrated fins added to the beater failed to improve the feeding

The 1954 ASAE Gold Medalists

The American Society of Agricultural Engineers Awarded the Cyrus Hall McCormick Medal to Wayne H. Worthington and the John Deere Medal to Raymond Olney at Minneapolis, Minn., on June 22



W. H. WORTHINGTON RAYMOND OLNEY

IN AT least its earlier years, the life story of the 1954 McCormick Medalist leans more to adventure than to engineering. Yet the span and scope of his professional career fulfills in gospel measure the inscription "For exceptional and meritorious engineering achievement in agriculture."

Wayne H. Worthington was born December 29, 1891, on a farm near Oskaloosa, Iowa. However, his agricultural heritage dates at least to the late 1600's, when Captain John Worthington settled in Maryland, across the Severn River from Annapolis, where for services rendered the English Crown, he had been awarded a large grant of land known as "Worthington's Courtesy." Shortly after the Revolutionary War, Wayne's forebears followed Daniel Boone into Kentucky. His mother, nee Minnie Barden, descended from the hard bitten, non-conforming Scotch-Irish immigrants who landed in northern Massachusetts and founded the town of Newburyport.

Wayne was still a youngster, an only child, when his father (James H.) took the family to Oklahoma shortly after the opening of the Cherokee Strip. To them, at the time, it offered little of the glamour of which Edna Ferber wrote in "Cimarron." Despite difficulties, Wayne was graduated at fifteen from the Perry High School.

At eighteen, and at the top of his class, he graduated in mechanical engineering at Oklahoma A. & M. College. Thus he had but two strictly college summer vacations. During one, he was "engineer" on a steam threshing "rig" in Kansas; and during the other he was an oiler on a steamer running between Galveston and New York. This is his only digression from agriculture.

Within a week after his graduation in June, 1910, he was on his way to Russia as a service engineer for the J. I. Case Company. In the five years that followed, Wayne worked throughout European Russia, in Siberia along the Trans-Siberian Railway south to the Outer Mongolian frontier, in Rumania, as well as in the small-grain growing areas of Argentina and Uruguay. He lived through the 1910 and 1911 epidemics of Asiatic cholera that swept the Ukraine and southern Russia, and was critically ill for eleven weeks with a ruptured appendix in the German hospital at Buenos

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IN SELECTION of the 1954 John Deere Medalist, the Jury of Awards of the American Society of Agricultural Engineers gives recognition to a man not for his discoveries or designs, neither for teaching or treatises in the technical realm of agricultural engineering. Rather, they honor a man to whom was early given a revelation of agricultural engineering as a new and needed profession, and who in turn has given the greater years of his life to the growth and service of that profession.

It was on a Sunday afternoon early in 1911 that Raymond Olney was browsing among the engineering magazines in the public library at Scranton, Pennsylvania. He read a brief account of the fourth annual meeting of the American Society of Agricultural Engineers, held in the prior autumn at Purdue University. He had not known of the Society, nor of any such sort of engineers, nor that already a few colleges offered courses in the subject matter.

But Ray had grown up as a farm boy in western New York. Behind him was a heritance dating back to 1635, when Thomas Olney came from England to settle in the Massachusetts colony, only to be excluded three years later along with Roger Williams. With eleven others they formed a new settlement at the head of Narragansett Bay and became the original thirteen proprietors of Providence, Rhode Island.

From his early high school years, young Raymond knew that he was to be an engineer, and in due course was graduated in mechanical engineering from Cornell University. In his senior year he had specialized in electrical engineering, looking toward a career in hydroelectric engineering. At graduation he entered employ of the Allis-Chalmers Mfg. Co. as student engineer, assigned to a plant building centrifugal pumps and water turbines, at Scranton.

Going again and again through that news item in the Scranton library, he had a vision of a lifework with fulfillment both of his engineering training and of his farm background. That very day he wrote to the secretary of the Society, who happened then to be J. B. Davidson, one of its founders and its first president. It was proposed that Ray should take a year of special work in agricultural engineering at Iowa State College, and earn a B.S. degree therein.

He never did get that degree, though many years later Iowa State conferred the professional degree of agricultural engineer. Making a quick pilgrimage back to the Cornell campus in quest of counsel, he met up with another M.E. graduate who had begun teaching "rural" engineering in the college of agriculture. With that contact, Ray's determination became firm, final and impatient, for that man was Howard W. Riley, another ASAE founder, and its fifth president.

Unwilling to await September and the start of an academic year, and unheeding of family and fiancé who agreed the whole thing was crazy, he wrote letters and wangled a job as farmhand at the experimental farm of the Hart-Parr Company, pioneer tractor builders at Charles City, Iowa. His boss was the late James A. King, then Hart-Parr publicity manager, and it was a rugged summer with the behemoths which were the tractors of 1911.

That fall, to "work his way" in part at Iowa State, Ray assisted in research projects by Matthew L. King, twin brother of James and a charter member of ASAE, who was then experimentalist in agricultural engineering in the agricultural experiment station. But even this scant year of special study in agricultural engineering was interrupted by still another legendary figure.

AN EARLY DAY "POWER FARMING EXPERT"

Lynn W. Ellis, predecessor of Arnold P. Yerkes in the study of tractor power for the U.S. Department of Agriculture, had joined the M. Rumely Company, at LaPorte, Ind., as a traction plowing specialist. In a mushroom expansion, led on by the immense success of its OilPull tractors, Rumely had bought out Gaar Scott & Company and the Advance Thresher Company, both noble names in the golden era of steam. Ellis became publicity manager for the merger. He came to Ames and "drafted" Ray Olney on the strength of his experience—running tractors the preceding summer—as a "power farming expert."

As an expert he was to write articles for trade papers and farm press, but before he was well started, Ellis dropped in his lap the editorship of the company's house organ. That task, too, was short-lived. When the zooming Rumely business dropped back, Ray dropped out, but he had begun to be an editor. Presently he was hired by the publisher of "Implement Age," Springfield, Ohio, to edit a new publication planned as "Modern Farm Power." Ray persuaded him to rename it "Farm Engineering."

In the swift rise and fall of ventures in those pioneer days of farm power, it too was destined to wither, though it lingered on some two years longer than did Mr. Olney. In January of 1915 he journeyed to St. Joseph and, as he puts it, "inveigled" E. C. Davidson, E. J. Perkins and James R. Stone into hiring him, part time, as assistant editor of their two publications. These were "Thresherman's Review and Power Farming" and "Gas Power."

A year later he became editor of both publications. At the same time, the name of the first publication was shortened to "Power Farming." Under his direction it became a guiding light in the general transition to tractor power, pushed along by World War I and its pressure for foods, notably breadstuffs. It was from "Power Farming" that came the amplified slogan, "Food will win the war; produce more with power."

Meanwhile "Gas Power," perhaps the first popular publication devoted entirely to the internal-combustion engine at its launching in 1903, had gone the usual way from an owner paper to a trade magazine. It was renamed "Power Farming Dealer," and its scope more sharply defined as thus implied.

Early in this sedately hectic career, in 1912, Ray had become a member of the American Society of Agricultural Engineers. At St. Joseph he could and did share more actively in its activities, recognized by election to its presidency for 1919. The Society had grown to feel keenly the need for something more than its annual "Transactions" to publish the expanding technology of the profession. Despite misgiving and difficulty, for it was in the agricultural collapse of 1920, decision was made to establish a monthly journal.

And "Journal of the . . ." it would have been, had not Raymond Olney been then on the governing Council, and thereby in position to urge the value of a short name. He proposed and persuaded adoption of the name AGRICULTURAL ENGINEERING. And not long after he had "named the baby," it became his baby indeed, for it stood in desperate need of professional nursing.

Publication had started with the issue for September, 1920. The late Dr. E. A. White was president-elect for 1921. He proposed that the new journal be brought under the wing of the Power Farming Press, not only for mechanical production but also for advertising sales representation, with Mr. Olney in general charge. He became editor and publisher beginning with the fifth issue, that of January, 1921. From then, right up to the continuing present, he has "put to bed" every issue of AGRICULTURAL ENGINEERING.

In November of that first year, the office of Secretary of the Society fell vacant, and Ray was appointed to fill it. It was then only a scant part-time job, and so the Society headquarters were brought to St. Joseph. In 1922 he was made Treasurer, and in 1925 his three-fold functions became a full-time job. Increase in Society membership and growth of AGRICULTURAL ENGINEERING made it more than full time. At the end of June, 1953, he relinquished the secretaryship.

EXPANDS PUBLICATION ACTIVITY

He did not take the lightening of his load for a letup. Forthwith he pushed toward something which for a decade had been his abiding dream—preparation and publication of AGRICULTURAL ENGINEERS YEARBOOK, which on May 1st of this year appeared in its first edition. And with separation from the sensitive implications of the secretaryship, he felt free to let his name be put in nomination for a medal award, which hitherto he had held to be hardly proper for the Society's "hired man."

Possibly because an editor's writing is largely piecemeal as well as perpetual, Mr. Olney includes no bibliography, makes no mention of authorship in the data furnished for the compiling of these paragraphs. Yet it was by presentation of a paper on "Standardization of Gas Tractors" that he came to notice of William Boss, a charter member of the Society, who remarks that Ray's "ability in working with people and in presenting the advantages of cooperative activity on the part of all groups concerned with a particular problem is probably the most important factor in the present healthy situation of the Society."

In like vein J. B. Davidson comments, "endowed by nature with the temperament and personality needed by a successful secretary who has many people to serve and please . . . it would be easy to believe that destiny picked Ray to be

secretary of the American Society of Agricultural Engineers."

Mr. Olney's wife is the former Elizabeth Watson, whom he married in 1912 at Rochester, New York. Their son, Ralph, was a casualty of World War II. Ray belongs to no fraternal, business, or social organization, and denies having any hobby—declaring that ASAE and its publications have been avocation as well as vocation for these thirty-odd years. In the local branch Church of Christ, Scientist, he was reader for three years, and for twenty years has been a teacher in its Sunday School.

Wayne H. Worthington

(Continued from page 501)

Aires. As opportunity permitted, he pursued advanced studies in mathematics and theoretical mechanics at the University of Moscow, delivered in the Caucasus the first American gas tractor sold in Russia, and was detained as a spy in England while trying to return home after the start of World War I.

In 1915, he joined the Aultman and Taylor Machinery Company of Mansfield, Ohio, primarily to design a grain thresher suited to Russian conditions, and gradually took over all engineering work on grain threshers, clover hullers and bean threshers. During the years 1917-19, Wayne was chief engineer for the tractor division of the Electric Wheel Company, of Quincy, Illinois, in charge of tractor design, development, tooling and methods. His work there included the design of a completely new kerosene-burning engine, unique in that no water was injected along with the fuel to control detonation, and the production of the first 2-3 plow tractor weighing under 4600 pounds.

Returning in 1920 to Aultman and Taylor as chief engineer, he continued with the Advance Rumely Company of La Porte, Indiana, when the two organizations merged in 1924. He was chief engineer of their Battle Creek (Michigan) Works until 1927, when he became manager of engineering for the parent company at La Porte. During these years, he directed pioneer studies into fatigue failures and methods to avoid stress concentrations, incorporation of the Duffee findings into ensilage cutters, transition of threshers and kindred machines from wood to steel construction, and the redesign of tractors to include fully enclosed power trains. Here, for the first time in tractor practice, he drew on the original German work of Hertz to design transmission gears in terms of surface compressive stresses.

In 1929, Wayne was consulting chief engineer for the Gleaner Combine Harvester Corporation of Independence, Missouri. To the original Gleaner "pull-type" combine (not the Fordson-mounted machine), he applied intensive development, introducing many innovations. It was a 12-foot machine, the first to weigh less than 6500 pounds, and its acceptance became legendary.

Then, in 1930, Wayne began his long and continuing connection with Deere & Company at the Waterloo (Iowa) Tractor Works. Yet what might seem like a "settling down" was but the beginning of further adventures, even if of a more sedate sort. For fourteen years, he was research engineer in charge of new design and development. In 1945-47 he became assistant chief engineer, and since 1948 has been director of engineering research.

This long period, with rich research resources at his command, along with commensurate responsibility, has been the harvest time of his life. Important achievements have grown from seed, some long dormant, sown in his earlier career. Among the inventions he has made, designs he has created and developments he has directed are many "firsts" such as: tractor engine which operated on kerosene (zero octane rating) without water injection and without detonation; controlled ventilation of tractor-engine crankcase; combustion chamber and manifolding affording controlled swirl to limit detonation when burning low-volatile fuels with poor combustion characteristics; the use of the toroidal combustion chamber in farm diesel engines; phase balancing of grain-thresher reciprocating parts, and the spring-balanced combine platform which provided full floating operation from any height from ground level up to thirty inches above.

Wayne's pioneer work with gears in tractor power trains includes "spread-center" spur gears, discovered while "setting up" a gear shaper, and developed empirically prior to available literature on involute trigonometry, and the use of long and short addendum bevel gearing in tractor differentials. Immediately following the publication of literature regarding involutometry, he was the first to employ variable-center and high contact-ratio spur gears, and to design such gears on the basis of surface compressive stresses experimentally evaluated.

In instrumentation, he originated electronic equipment for measuring and recording power simultaneously at engine, drive axles and drawbar, also hydraulic and electronic means for defining the line of draft and measuring and recording the draft of tractor-mounted implements. Sharing in the safety activities of the Farm Equipment Institute, he added substantially to the mathematical procedures for investigating the stability of rubber-tired tractors.

PROFESSIONAL SOCIETY ACTIVITIES

Wayne became a member of the ASAE in 1921, served as its vice-president in 1930, and for some years has been a member of the Steering Committee of the Power and Machinery Division. He topped the list of ASAE Paper Awards winners in 1950, and was elected a Fellow of ASAE in 1953. In the Society of Automotive Engineers, he has been a member since 1917, served as vice-president in 1950, has long been a member of the Tractor Technical Committee and many technical subcommittees, as well as the SAE Technical Board. He is also a member of the American Statistical Association and of the Max Eyth Gesellschaft, a German engineering organization somewhat comparable to the ASAE. He is active in the work of the Engineering Advisory Committee of the Farm Equipment Institute.

One little known facet of Wayne's activities, but of no less enduring significance than his engineering achievements, remains largely anonymous. This has been his encouragement and guidance of young men during their hours of decision, as they stood in doubt at life's crossroads. With keen insight he recognized their abilities and appraised their talents. His faith and persuasions have inspired many with hope and confidence and the determination to finish their education. Patiently and tirelessly his efforts have been directed toward finding ways for these to proceed with and complete their education, and work on into positions of trust and responsibility. Others in their high school or college years, as young men striking out at the start of their careers, and many well advanced in experience, have found his understanding and counsel always to be had for the ask-

ing. Among these are not a few of today's outstanding engineers. Many started their careers within the orbit of Wayne's influence and direction. By precept, guidance and example, his influence extends in ever-widening circles among his contemporaries and associates.

Recalling one amusing incident, Wayne relates how one young GI, returning from the Far East in 1946, was a few days too late to matriculate in any engineering college. At midnight, calling the dean of engineering of his Alma Mater, Wayne told of this young man's excellent high school record, his struggle against poverty, his splendid work as a student draftsman while accumulating enough money to go on to college, his study of mathematics by correspondence from the University of Iowa while on the "Islands," and followed this by an impassioned plea that some way be found to allow this "boy" to matriculate. Sleepily came the reply over the telephone in a deep Southern drawl, "We all don't have any place to keep this boy, our classrooms are filled up, there aren't even any books for him to study, and he's already late, but send him on down—if he's as good as you say he is, we'll take care of him somehow." Winning his degree *cum laude* and subsequently pursuing advanced studies, this young man has already made significant contributions in his work as a scientist, with the Bell Telephone Laboratories.

Mr. Worthington and his wife, who was Edith Peterson of Wisconsin, have three daughters and one son, all married, and five grandchildren. Their second child, a son, died at birth. The Worthington's belong to the Westminster Presbyterian Church; he is a member of the John Deere Supervisors Club and has been a 32nd-degree Mason since 1930.

Wayne says he has "little interest in golf, and even less in sports vicariously enjoyed. Horseback riding is something else again." The hobby he most enjoys is vacationing in the remote reaches of Arizona, New Mexico, Utah and Colorado. Another, which gets more time, is studying contemporary foreign engineering literature in its original languages. He maintains correspondence with many engineers abroad.

From the warmth with which he was commended as a candidate for the McCormick Medal, there is evidence aplenty of the admiration and esteem, approaching affection, wherein Wayne is held by his colleagues. Letting one speak for many, "Wayne merits this attention, not only for his 'firsts' in engineering and his many accomplishments, but also for leadership in disseminating engineering information of general interest through papers presented at professional societies, and his activities in engineering committees working on standards, etc. In many of these activities it was his patience, counsel, and engineering prestige which carried projects to successful conclusion, even though he was not official head of all the committees involved. Wayne's unfailing kindness, and his ever being ready to advise, encourage and assist younger engineers have advanced his stature."

Combining Corn

(Continued from page 500)

Results in Terms of Corn Losses

Efficiency tests of the combine and attachment were made in check-rowed corn yielding 80 bu per acre. Kernel moisture was 18 percent. The stalks were green, heavy, about ten feet tall, and sixteen percent of the plants were lodged to the point where the ear was touching the ground. The total loss consisted of ears not picked up, corn left on the cobs, shelled corn lost at the cutter bar, shelled corn lost over the deck and over the shaker shoe, all of which are shown in Table 1. Three tests were made in full height corn and three in corn topped at six feet. No significant difference in results was noted.

TABLE 1. CORN LOSSES* IN COMBINE TEST

	Losses (Percent of total yield)					
Corn height	Ears	Unshelled	Cutter-bar	Over shaker shoe	Over deck	Total
Full (10 ft)	4.4	0.3	0.4	0.1	1.4	6.6
Topped at 6 ft	3.0	0.2	0.4	0.08	1.7	5.4

*All figures are percent of total yield, which averaged 82 bu per acre. Ear corn losses are converted to equivalent shelled corn. Figures are average of three tests.

From these results it will be seen that by far the major losses were in ears and shelled corn carried over the deck in the stover. The auger attachment picked up stalks lodged at right angles to the row but missed many of the stalks lodged in the direction of the corn rows. Though only one row was being harvested the mat of stover on the deck was too thick to let the corn fall through, particularly with the limited agitation provided by the one piece deck. Corn stover is heavy and requires violent tossing to assure effective separation.

Loss "at the cutter bar" was due to two causes. Kernels were picked up by the beater in front of the cylinder, and since it was exposed, many of these kernels were thrown out onto the ground ahead of the machine. The feeder canvas carried kernels on around and some of these were flipped up and lost at the lower roller of the feeder. Replacement of the beater cover and a slight change in the sheet metal cover over the lower roller of the feeder would almost eliminate these losses.

CONCLUSIONS

Following are the conclusions drawn from the 1953 experience with this combine and attachment:

1 The auger system is quite satisfactory in pushing the standing stalks back onto the combine feeder.

2 The augers pick up corn lodged crosswise of the row. They are smoother in action than gathering chains so fewer ears are shaken off.

3 The augers pick up very few of the stalks lodged parallel to the row.

4 The slatted canvas-type feeder is not positive enough to assure even feeding.

5 The cutter bar should be farther from the beater. This means that the feeder should be longer, but it is perhaps impractical to have a feeder long enough for ten-foot stalks.

6 Losses over the deck suggest the advantage of passing only the ears through the combine, particularly if two, three or four rows are to be harvested. However, combines with straw walkers may be able to handle much larger quantities of stover without loss of corn.

7 Cylinder capacity seems to set no limitation on the use of the combine to harvest corn, either ears alone or handling the whole plant.

8 Corn harvesting with combines is feasible and the problem of getting the corn into the combine is the major problem at this time.

INSTRUMENT NEWS

KARL NORRIS, Editor

Sponsored by the ASAE Committee on Instrumentation and Controls. Contributions on agricultural applications of instruments and controls and related problems are invited, and should be submitted direct to K. H. Norris, Agricultural Research Center, Beltsville, Md.

A Relative Humidity Probe

C. P. Hedlin
Assoc. Member ASAE

THE relative humidity probe described here was constructed for use in hay drying research at the Ontario Agricultural College. It was used to sample air at any desired point in the hay in a mow in order to determine the psychrometric quality of the air.

Construction

The basic parts of the unit were (a) two thermocouples, (b) a potentiometer, (c) a relative humidity gage, (d) a ½-in pipe, (e) a small fan or air pump, and (f) a box to contain the relative humidity gage and the fan.

The relative humidity gage was a direct-reading unit with a moisture sensitive membrane.

A pipe is placed in the hay at the time of loading the mow so that it will convey air from a selected point to the measuring unit outside the hay. One thermocouple is placed in the hay to measure air temperature at the point to be sampled. The pipe is connected to a box containing the relative humidity gage and the fan. The second thermocouple is placed near the sensitive element of the relative humidity gage. Air flows through the pipe into the box which is so constructed that air enters it only from the pipe.

The flow of air through the unit may be caused either by static pressure in the hay resulting from the operation of the hay-drying fan, or it may be caused by the small suction fan. The total pressure required for sufficient air flow is at least 0.25 in w.g. With proper air flow a steady relative humidity reading can be obtained in approximately two minutes. The relative humidity reading is taken by observation through a glass window in the box. The temperature of the air at the relative humidity gage is measured with the thermocouple and potentiometer.

The author—C. P. HEDLIN—is lecturer, agricultural engineering department, Ontario Agricultural College.

The humidity ratio of the air is determined from the relative humidity and temperature in the box. If the humidity ratio is assumed to be the same in the box as it is at the point of sampling, the condition of the air in the hay can be determined by using the temperature in the hay.

The purpose of experimentation has been to investigate changes in air quality and for this reason a number of pipes have been placed so that sampling can be done at intervals along the path of the air. From the information obtained, curves can be drawn indicating the approximate psychrometric quality of the air at any point.

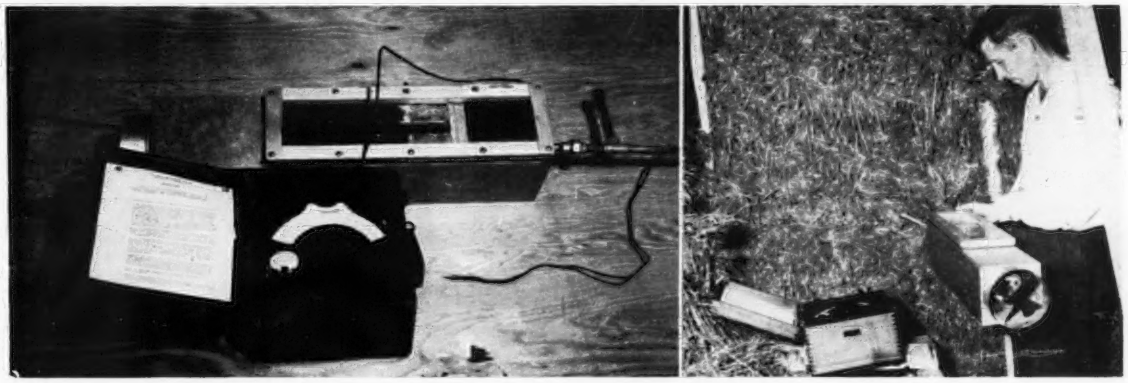
The length of time during which air must be in contact with hay before it reaches equilibrium relative humidity depends in part on the temperature and relative humidity of the air, on air velocity, and on the moisture content of the hay. The time interval required for cool air to reach equilibrium relative humidity is quite short. If the air is supplied at a relatively high temperature the required time interval is longer. If the air velocity is high, it may pass through the hay without picking up all the moisture it is capable of removing. An increased knowledge of the relationship between air quality, hay condition, and air velocity may aid in the design of systems which allow for a maximum efficiency in the use of available fan capacity and power.

Human-Engineering Aspects of Safety

THE "human-engineering" approach to the solution of the accident problem is to build machines and working areas around the operator, rather than to place him in a setting without regard to his requirements and capacities. Unless this is done, it is hardly fair to attribute so many accidents to human failure as is usually the case.

One of the most important ways of improving safety is to design equipment in terms of human capabilities and limitations. Radios do not hear; radar doesn't see; guns don't point, any more than automobiles drive themselves. Difficulties arise when mechanization becomes too complicated for human operators.

More precisely stated, the engineer must have an understanding of the sense organs and the characteristics of human perception if satisfactory information is to be supplied from sounds and lights in the operation of equipment. In general, man is a poor monitor of equipment.—R. A. McFarland in *Mechanical Engineering* for May, 1954.



The relative humidity probe unit shown at the left and in use at the right

NEWS SECTION

Minnesota Meeting Sets New Records

SATISFACTION with the 47th Annual Meeting of ASAE at Minneapolis, June 20-23, was general and evident in the remarks and expressions of the large crowd attending.

In planning and handling the meeting the Minnesota Section lived up to its adopted meeting slogan, "More in 54."

It attracted a larger attendance than any annual meeting in the past several years. A tally on Wednesday afternoon showed a total registration of 942 men, women, and children.

It offered an intensified program with more time for technical division sessions than has been provided in other recent annual meetings, and a popular line-up of special events.

Registration beginning at 1:00 p.m. Sunday, June 20, and continuing through the afternoon and evening minimized peak loads and delays in getting the crowd set to enjoy the meeting.

Carefully planned preregistration and a strong response on the part of members helped the Local Arrangements Committee match food and facilities to the numbers to be entertained at special events.

A daily bulletin by the Public Relations and Local Arrangements Committees was a popular new feature of the meeting. Copies available at breakfast provided reminders of special events scheduled for the day, and comments on activities of the preceding day.

A buffet supper Sunday evening in the main ballroom at Coffman Memorial Union drew an attendance of several hundred. Following the supper a professional prestidigitator and pickpocket temporarily and repeatedly victimized several volunteers, to the delight of the audience. He lifted and returned billfolds and wrist watches repeatedly, while maintaining a running fire of conversation; relieved one of the victims of his belt and shirt in a few deft moves, and apparently removed from various pockets some treasured personal mementos not intended for public view.

The St. Anthony Falls Hydraulic Laboratory proved a popular and appropriate setting for the Monday forenoon session of the Soil and Water Division. Box lunches made available there, and a conducted inspection trip through the laboratory in the afternoon enabled many visitors to spend most of the day studying its setup and research program..

Interest in the Monday afternoon inspection trips was emphasized by the long line of chartered buses loading in front of the Union Building at 1:00 p.m. There were at least two bus loads for each of the three special trips, in addition to those who stayed over at the Hydraulic Laboratory to give it a thorough inspection.

Weather was ideal for the barbecue Monday evening at the University Farm, in St. Paul, and for the square dance which followed. Multiple serving lines worked at top speed for an hour or more to feed the large crowd turning out for the barbecue.

The College Division held its own in competing for attention in its sessions held concurrently with those of the technical divisions.

Tuesday morning's committee meeting and special program period from 8:30 to 10:00 helped to clear the way for full attendance at the main sessions and evening entertainment.

In the General Session on Tuesday afternoon the President's Annual Address, by Edwin W. Tanquary, reviewed a year of notable progress in the Society and in agricultural engineering as a branch of the engineering profession.

Addressing the session on "New Horizons," John Ransom, director of product research and training, Minneapolis-Moline Co., challenged agricultural engineers to broaden their field and intensify their applications of engineering in service to agriculture and the general public in every possible way.

He was followed by E. E. Nelson presenting the winning student paper, entitled "Soybean Losses at the Cutting Bar of the Combine."

Reports of committees and officers of the Society, appraising progress during the past year and plans for the following year, were featured in the annual business meeting.

A capacity crowd of more than 600 attended the ASAE Annual Dinner and were royally entertained. Leonard J. Fletcher, fellow and past-president of ASAE, and vice-president of Caterpillar Tractor Co., was master of ceremonies. Following a steak dinner the Schieks Singing Sextet presented a number of selections from "Okla-

ASAE Meetings Calendar

August 24-26—NORTH ATLANTIC SECTION, University of Vermont, Burlington

October 14 and 15—PACIFIC NORTHWEST SECTION, Davenport Hotel, Spokane, Wash.

December 6-8—WINTER MEETING, Edgewater Beach Hotel, Chicago.

June 12-15, 1955—48TH ANNUAL MEETING, University of Illinois, Urbana

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Leonard J. Fletcher, vice-president, Caterpillar Tractor Co.—past-president of ASAE in 1931-32 and Cyrus Hall McCormick medallist in 1944—presided as master of ceremonies at the ASAE annual dinner in Minneapolis which was attended by 550 ASAE members and guests. Mr. Fletcher was also guest speaker at the complimentary luncheon sponsored by the Farm Equipment Institute for agricultural engineering students attending the ASAE Annual Meeting.

(Left) A surprise visitor at the 1954 ASAE Annual Meeting in Minneapolis last month was Dr. Charles F. Kettering, who is shown here being welcomed by John H. Wessman, a member of the Committee on Public Relations. Dr. Kettering was in Minneapolis to address a group of newsmen and agricultural engineers in connection with the introduction of the Oliver XO-121 farm tractor, which is equipped with an experimental engine that has a 12-to-1 compression ratio and burns 107-octane fuel. Others in the picture are, extreme left, Ken W. Westerberg, in charge of the publicity setup for the meeting, and Chas. Gellerman of the Alfred Colle Co. • *(Right)* Another view of Dr. Kettering flanked by Indian princesses Peggy Otis and Patty Westerberg who served as members of the committee to welcome him to the ASAE Annual Meeting

(Left) The new ASAE President for the Society year 1955-56, George B. Nutt, center, welcomes two charter members of the Society at the annual dinner. On Mr. Nutt's right is J. B. Davidson, professor emeritus of agricultural engineering, Iowa State College, and first president of ASAE. At Mr. Nutt's left is William Boss, former head of the agricultural engineering department, University of Minnesota, who served ASAE as president in 1928-29 • *(Right)* As his last official act, ASAE President E. W. Tanquary inaugurates the new Society president, George B. Nutt, into office. Mr. Nutt is head of the agricultural engineering department, Clemson Agricultural College, Clemson, S. C.

homa" in a brief between-shows appearance.

Dr. Kenneth McFarland, educational consultant and lecturer, General Motors Corporation, was the speaker of the evening. In an address entitled "Thinkin Tall" he emphasized a great deal of food for thought on current domestic and world problems, with a smooth, rapid-fire delivery and good humor.

In addition to introducing those at the speakers table, Mr. Fletcher called attention to the five surviving charter members and presented the two, Dr. J. B. Davidson and William Boss, who were present. He also had all past-presidents of the Society who were present stand and be recognized.

In presenting annual awards, President Tanquary first called attention to those listed in the dinner program. He then called special attention to the Cyrus Hall McCormick Medal and presented it to W. H. Worthington. After brief acceptance remarks the John Deere Medal was similarly presented to Raymond Olney, and accepted by him.

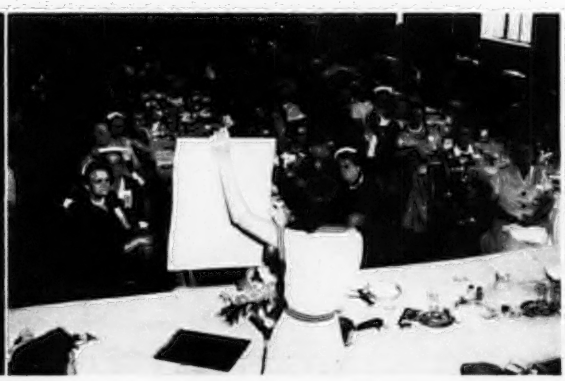
Among the Journal paper awards for papers judged best among those published in AGRICULTURAL ENGINEERING in 1953, the winners were "Electric Color Sorting of Fruits and Vegetables," by J. B. Power, J. T. Gunn, and F. C. Jacob; "Lethal Effect of Electrons on Insects Infesting Wheat and Flour," by V. H. Baker, Oscar Taboada, and D. E. Wiant; "Electronic Detection and Removal of Tramp Iron from Chopped Hay," by John B. Dobie, Frederic C. Jacob, and Leroy C. Kleist; "Corn Shelling with a Combine Cylinder," by D. F. Hopkins and Geo. E. Pickard; and "Soil Mixing Characteristics of Tillage Implements," by W. C. Hulburt and R. G. Menzel.

The list of Student Honor Award winners, for scholastic attainments and student activities, included Dean E. Booster, Oregon State College; Stanley J. Clark, Kansas State College; Barry S. Crafts, University of Maine; Julian Goff, North Carolina State College; Carl Hays, Oklahoma A. & M. College; Donald Jagger, Michigan State College; Gordon Kruse, University of Nebraska; Donald R. Longabach, Kansas State College; Curtis L. Mennenga, Iowa State College; W. Ralph Nave, University of Tennessee; Phillip R. Ourada, University of Idaho; Max J. Petzenhauser, Iowa State College; Cletus Schertz, University of Illinois; Frank Shepard, North Carolina State College; Donald D. Seath, Iowa State College; Delmar Van Meter, University of Missouri; Dean R. Vilander, State College of Washington; Rolland Z. Wheaton, Michigan State College, and Peter P. Zinchuk, University of Maine.

Student Paper Awards went to P. A. Konneker, Illinois Student Branch, for a paper on "Separation of Ground Feeds Discharged from Mechanical Conveyors"; E. E. Nelson, Ohio Student Branch, for a paper on "Soybean Losses at the Cutting Bar of the Combine"; and D. Suter, Oklahoma Student Branch, for a paper on "Pole Stability." Based on presentations of these papers at the Monday morning Student Session a committee of officers of the Society selected the paper by E. E. Nelson for top honors. R. H. Meier, M. W. Forth, and P. R. Bakes constituted the Committee on Student Paper Awards which selected the three winners.

A strong student program arranged by

(Left) ASAE President E. W. Tanquary presents the 1954 Cyrus Hall McCormick Gold Medal award to Wayne H. Worthington, director of engineering research, John Deere Waterloo Tractor Works • *(Right)* H. S. Pringle, USDA Agricultural Extension Service and vice-chairman of ASAE Committee on Extension, presents a blue ribbon award to Frank J. Reynolds, manager, agricultural extension, U.S. Steel Corp., for one of the prize winning publications issued by his company and displayed at the exhibit which was a feature of the ASAE Annual Meeting



(Left) C. Ivan Branton, at left, of Alaska and ASAE President E. W. Tanquary, center, introduce Dr. Walter Soehne, of Braunschweig, Germany, to the wonders of an American barbecue. • *(Right)* A view of the get-acquainted luncheon for the ladies attending the 47th ASAE Annual Meeting. Between 300 and 400 women and children were in attendance at the meeting

officers of the National Council of Student Branches and the Committee on Student Branches was well attended by representatives from a majority of the organized branches. In addition the Local Arrangements Committee provided a special luncheon Tuesday noon for the students and officers of the Society. The Farm Equipment Institute luncheon Wednesday noon featured announcement of the branches winning the FEI Awards. The cup for class A, the larger student branches, was awarded to the Branch at the University of Maine and the Pennsylvania Student Branch was awarded the cup in the competition among the smaller branches.

Officers of the National Council of Student Branches elected for 1954-55, were:

Orlean Moe, Minnesota, president; John Replogle, Illinois, 1st vice-president; Barry Crafts, Maine, 2nd vice-president; and Kenneth Campen, Missouri, secretary.

Ladies and children present were given the opportunity to make the most of their visit, with a schedule almost as full as that provided for the men. A women's get acquainted luncheon Monday noon, the Donna Mae cruise Tuesday, a children's dinner party Tuesday evening and inspection trips Wednesday to the Creamette Co., Munsingwear Co., and a tour of the Twin Cities, along with the family events Sunday, Monday, and Tuesday evenings, all proved popular.

The program and exhibits sponsored by the Committee on Extension are reported separately.

Alabama Section Elects Kummer

FRED A. KUMMER, head, agricultural engineering department, Alabama Polytechnic Institute, was elected chairman of the Alabama Section of the American Society of Agricultural Engineers at a meeting of the Section at Tuscaloosa, Ala., on May 14 and 15. He succeeds H. M. Schudt, general manager, Gadsden, Ala., Works, Allis-Chalmers Mfg. Co.

Lowell Stoddard, owner, Stoddard Tractor Co., Decatur, was elected the new vice-chairman of the Section. Elmo S. Renoll, assistant professor of agricultural engineering, Alabama Polytechnic Institute, was elected the new Section secretary. The Section also elected a reporter, Hurst Mauldin, senior agricultural engineer, Alabama Power Co., Birmingham. The new Nominating Committee includes Tom E. Corley and A. C. Rogers, Jr.

Approximately 70 members and friends of the Alabama Section attended the meeting at which was presented an excellent program, one of the outstanding features of which was the address of ASAE President E. W. Tanquary, who discussed some of the challenges facing agricultural engineers in the future and presented some interesting facts on the growth of the Society. President Tanquary's address was followed by a motion picture showing the endurance tests to which newly developed farm machines are now being subjected by more and more equipment manufacturers.

Other talks on the formal program included one by V. M. Shamburger, Jr., of the Alabama Oil and Gas Board, on Alabama's oil. The subject of Alabama's water was discussed by Phillip B. Lamoureaux of the U.S. Geological Survey. An interesting description of the potential uses of atomic energy in the field of agriculture was given by Eric Rodgers of the physics department of the University of Alabama.

On the first day of the meeting, the group toured the plant of the Central Foundry Co. of Tuscaloosa, which produces more than 3000 miles of soil pipe per year. The tour also included the plant of the Gulf States Paper Corp. near Tuscaloosa where the group saw pulp wood being processed into finished paper. Following the tour, the Company was host to the Section for a boat ride on the Black Warrior River.

On the second day of the meeting, the group toured the modern milking barn of J. Lester Lee, a farmer near Tuscaloosa, and also the dairy and broiler farm of Herman B. Worsham.

The next meeting of the Section will be on or about October 1 and will be held at Gulf Shores, Ala.

ASAE North Atlantic Section Meets in August

THE North Atlantic Section of the American Society of Agricultural Engineers will hold its regular yearly meeting August 24, 25 and 26 on the campus of the University of Vermont at Burlington. Arrangements are being made to accommodate those attend-

(News continued on page 510)

Snapshots taken at the ASAE Alabama Section meeting May 14-15. The group on the left includes *(left to right)* H. M. Schudt, Section chairman; E. W. Tanquary, 1953-54 President of ASAE; A. W. Cooper, first vice-chairman, Southeast and Alabama Sections; Rex Colwick, secretary, Southeast Section; and F. A. Kummer, chairman-elect, Alabama Section. The group on the right includes Alabama Section members and visitors attending the meeting. *(Left to right)* E. O. Kimbrough, Jr., Mississippi State College; S. H. Booker, chairman, local arrangements committee for the meeting; J. T. Gaillard, extension engineer, Alabama Polytechnic Institute; E. H. Wilson, agricultural representative, Alabama Chamber of Commerce; J. L. Butt, secretary, Alabama Section; and M. B. Penn, chief agricultural engineer, Alabama Power Co.

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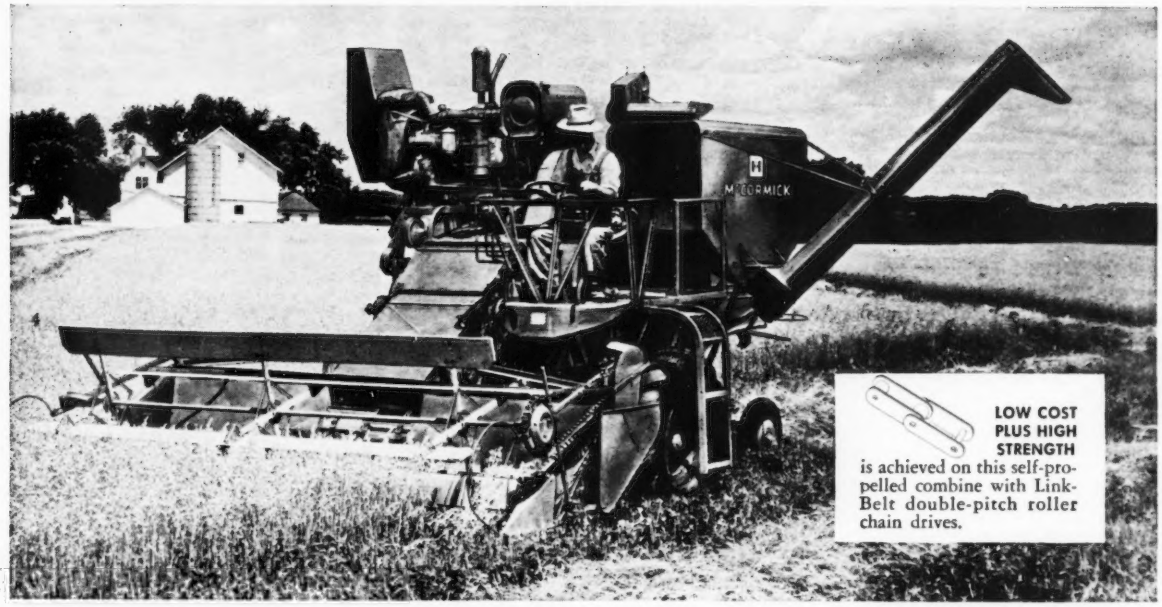

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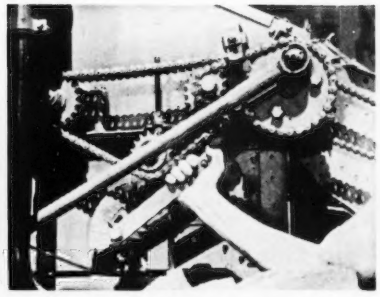

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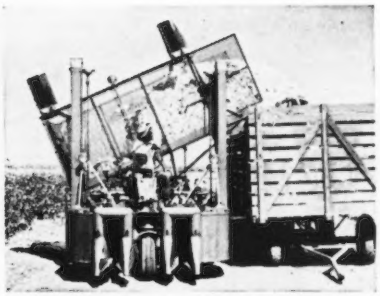

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NEWS SECTION

(Continued from page 508)

ing the meeting in the dormitories on the campus. Accommodations in Burlington hotels as well as tourist homes and motels will also be available to those attending the meeting.

An extensive and interesting program is being arranged for the meeting. The special power and machinery program is being prepared under the direction of Guy E. Woodward, New Holland Machine Co.; the soil and water program by B. L. Bondurant, extension agricultural engineer, University of Delaware; and the rural electric program by M. E. Singley, associate professor of agricultural engineering, Rutgers University.

A special all-day program on August 26 will be devoted to the subject "Forage Crop Production." The program is being arranged by O. C. French, head of the agricultural engineering department, Cornell University. The forenoon session will be devoted to the latest developments of research and equipment in this field which will be followed in the afternoon by the experiences of several farmers and new field practices. It is expected the program will give comprehensive treatment of this important subject.

Complete information concerning the program, accommodations, etc., for this meeting will be supplied on request to the secretary of the Section, C. N. Turner, agricultural engineering department, Cornell University, Ithaca, N. Y.

Texas Tech Curriculum Recognized

TEXAS Technological College at Lubbock has instituted a curriculum in agricultural engineering which the ASAE Council recently recognized as having full professional status.

This action was taken by the Council to identify the College and its agricultural engineering department as qualified to maintain a recognized Student Branch of ASAE. The curriculum has been compared favorably with other agricultural engineering curriculums accredited by ECPD and with other engineering curriculums at Texas Technological College which have been similarly accredited.

Ira L. Williams is head of the department. Other personnel in the department are Charles T. Bourns, associate professor, and Eldred A. Jordan, instructor in farm shop.

The agricultural engineering student group is preparing to petition for recognition as a Student Branch of ASAE.

Dean Dolve Retires

COMPLETING 46 years of service to the State of North Dakota, North Dakota Agricultural College, and the engineering profession, R. M. Dolve retired last month from his position as dean of the school of engineering at NDAC, a position which he has held for many years.

At the 1954 commencement exercises of the College on June 7, Dean Dolve was awarded the Honorary Doctor of Science Degree, and on that occasion addressed the graduating class.

At the first annual meeting of the American Society of Agricultural Engineers at Champaign, Ill., in December, 1908, the name of Dean Dolve was included on the official list of charter members of ASAE adopted by the Society at that meeting. He has not, however, been an active member of the Society for many years.

Extension Exhibits at Annual Meeting

EXHIBITS at the 1954 ASAE Annual Meeting of a variety of extension materials from public service and industrial organizations all over the country, together with displays provided by industries in the Minneapolis area, drew a continuing audience throughout the periods before and after sessions and other special events. Blue ribbons were awarded by the Committee on Extension for items judged to be especially meritorious in several classes of exhibits.

Motion picture exhibits were in charge of B. Parker Hess. Two blue ribbons were awarded. They went to "Farm Petroleum Safety," produced by the Committee on Agriculture, American Petroleum Institute, entered by C. N. Hinkle; and to "Green Gold," produced by the Agricultural Extension Bureau of Republic Steel Corporation, entered by Earl D. Merrill.

Slide and film strip entries were in charge of E. A. Olson. Blue ribbon winners were "A Sanitary Power Pump Platform for the Farm Water System," produced by the Nebraska Agricultural Extension Service; and "The 4-H Farm and Home Electric Program" produced by Westinghouse under the supervision of R. F. Scott.

A total of 12 entries of demonstration models, exhibited under the direction of Frank W. Andrew, occupied a major part of the exhibit space and stimulated a great deal of interest. A model barn exhibited by the Structural Clay Products Institute; a dairy barn ventilation model, by the Midwest Plan Service; and an electrified model farmstead, by the Northern States Power Co. were awarded blue ribbons.

Publication exhibits were divided into industrial and public agency groups. Ribbon winning industrial bulletins included "Steel Buildings for Practical Farmers," published by the U.S. Steel Corp and entered by Frank J. Reynolds; "Take a Look at This Big Market for Thermopane Insulating Glass," a Libbey-Owens-Ford bulletin entered by W. E. Eakin; "Good Application Makes a Good Roof Better," an Asphalt Roofing Industry Bureau item entered by J. S. Bryant; and "How to Build a Reynolds Portable Cattle Shelter," a Reynolds Farm Institute publication entered by Charles Walte, Jr.

In the public agency group awards went to "Handling Silage and Concentrates for Beef Cattle in Drylot," an Illinois circular by R. S. Van Arsdall and Thaver Cleaver; "More Power to You," a California 4-H electric project bulletin by Ralph R. Parks; "Planning Farm Fences," by G. E. Henderson, published by the Southern Association of Agricultural Engineering and Vocational Agriculture; and "Loose Housing for Dairy Cattle," a USDA agricultural information bulletin by Thayer Cleaver and Robert G. Yeck. Arnold Nicholson was in charge of the publications exhibits.

Among extension method outlines exhibited under the direction of R. L. Ricketts, winners were the South Carolina grain conservation program, "Save more in 54," entered by G. H. Stewart; Virginia's water systems program for 1954, entered by J. L. Calhoun; and the Iowa lumber dealers and rural builder's short course, entered by Ralph W. Hansen.

Twenty-nine new textbooks were entered in that section of the exhibit, arranged by J. P. Schaenzer. Due to the wide range of subject matter covered and other obstacles to direct comparison of these works, no awards were made in this class. However, a great deal of interest was shown in the books exhibited.

Letter to the Editor

Ag Engineer Writes from India

TO THE EDITOR:

I have assumed the duties of head of the agricultural engineering department here at the Indian Institute of Technology. The assignment is for the next two years by the University of Illinois on a "sisterhood" arrangement between the two institutions. Dr. J. L. Haugh, a geology professor, and I are the first two University of Illinois men to be assigned here.

Enroute here we spent several days with Aldert Molenaar with the FAO of the UN in Rome and with Earle K. Rambo, foreign agricultural engineering advisor of OFAR in Lebanon, and with the American TCM and Embassy staff in New Delhi. We were also at Allahabad Agricultural Institute with Mason Vaugh and his fine staff. At Allahabad, four University of Illinois staff members in crops, dairy, home economics and extension are also working on a similar sisterhood contract. We have also seen J. Dewey Long in Calcutta and found him busy and happy.

Here at IIT, I am in a strictly engineering institution with no other work in agriculture, than ours, being taught. At present we have only two lectures, one in botany and crops and the other in farm machinery. We have some mechanics and other non-academic staff, and also fifty interested and eager first and second-year students. We expect 30 to 40 more students when the new term starts in July. Our immediate need is to fill at least six positions on our teaching staff and also develop laboratory facilities and farm some idle land for teaching and research purposes. Director S. R. Sen Gupta, a civil engineer by training is much interested in helping us. The entire staff here is exceptionally well qualified, many of them having graduate training in America.

RALPH C. HAY
Kharagpur, West Bengal, India

1954 Farm Safety Poster

Pictured above is the safety poster issued by the Farm Equipment Institute which is being widely publicized by the farm equipment industry to focus nation-wide attention on the significance of National Farm Safety Week, July 25-31, in the interest of greater safety in agriculture.

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NEWS OF ASAE MEMBERS

Harry B. Walker, emeritus professor of agricultural engineering and agricultural engineer in the experiment station of the University of California at Davis, was honored last month at the 91st commencement ceremonies on the Berkeley campus of the University of California, when he received the honorary Doctor of Laws degree for distinguished service in the field of agricultural engineering.

Harry B. Walker

Mr. Walker joined the faculty on the Davis campus in 1928, after serving as head of the agricultural engineering department at Kansas State College. While in Kansas he had also served as irrigation engineer for the state. He also served a long term as chairman of the California Committee on the Relation of Electricity to Agriculture. He retired in 1951.

As a vice-president of the American Society of Agricultural Engineers, Mr. Walker served as acting president of the Society during the year 1924-25 following the tragic death of F. W. Ives. Later, in 1942-43 he was elected and served as president of the Society. He also served as chairman of the College Division in 1927-28. In 1939 he was awarded the John Deere Gold Medal, the second recipient of this medal.

Since 1928 when Mr. Walker joined the agricultural engineering staff in California, he has contributed much to the upgrading of research in agricultural engineering, as well as along academic lines in the professional curriculum. The agricultural engineering curriculum at Davis was the first to be accredited by Engineers' Council for Professional Development, which at that time was an option in mechanical engineering. He has ever been a strong proponent of group and cooperative research and a believer in a broad cultural education, along with technical training.

Professor Walker was chairman of a committee appointed by President R. G. Sproul of the University of California to work out the place and scope of a college of letters and science for the campus at Davis, which has been established. He likewise served in the same way in establishing the University liberal arts college on the University campus at Riverside, and he has served on President Sproul's Advisory Council and on many committees of the academic senate. As expressed by President Sproul in awarding the honorary degree, Mr. Walker has prepared the way for the elimination of gadgetry in farm equipment and the development of engineered agricultural machinery which has advanced the economic status of farmers and increased the comforts of rural living. Professor Walker is the first member of the faculty on the Davis campus to be honored by the Doctor of Laws degree.

Verne R. Hillman, executive officer of the Virginia State Conservation Committee, has accepted a two-year appointment with the Foreign Operations Administration and expects to leave by early May for a post at Bogor, Indonesia.

Joseph Bornstein who has served the past four years as an agricultural engineer of the U.S. Soil Conservation Service first at Chelmsford, Mass., and later at Plattsburg, N. Y., was recently promoted to the design section of the engineering and watershed planning unit, as design engineer, at Upper Darby, Pa.

George V. Frushour, until recently employed as an engineer on forage harvesting equipment with the Tractor and Implement Division, Ford Motor Co., recently accepted a position as product engineer at the Anniston, Alabama, works of the J. I. Case Co.

Eddie F. Kenny, who has been employed in sales and service work for the Golightly Motor Sales at Mitchell, Ontario, Canada, recently resigned to engage in teaching in the elementary public school at Mitchell and in cash crop farming.

Chris Nyberg, who recently retired as chief engineer at the Battle Creek plant of The Oliver Corp., has undertaken special engineering work with the Tractor and Implement Division of the Ford Motor Co., at Birmingham, Mich.

Harold E. Pinches resigned his position as assistant to the executive vice-president of Harry Ferguson, Inc., effective March 1, to become director of research and a member of the executive committee of American Kitchens Division, Avco Manufacturing Corp., Connersville, Ind.

Julian M. Fore, has joined the organization of the Ford Motor Co., Tractor and Implement Division, at Birmingham, Mich. He was formerly with Aerovent Fan and Equipment Co. at Lansing, Mich.

M. Lee Gustafson recently resigned as irrigation sales engineer for Tart-Ide Corp., to become junior design engineer at the Hopkins, Minnesota, plant of the Minneapolis-Moline Co.

P. J. U. Bornman, a farmer and agricultural consultant of the Bornman Engineering Co. at Barberton, Transvaal, South Africa, was recently appointed a part-time lecturer on mathematics and engineering drawing for all technical classes at the Barberton Technical School.

Stanton R. Morrison has resigned as assistant agricultural engineer at the Rice and Pasture Substation, Texas Agricultural Experiment Station, to accept a position as rice officer with the department of agriculture of the government of British Honduras. He will be located with the department offices at Belize.

Liston N. Drury has been appointed instructor in the agricultural engineering department at the University of Tennessee. He was formerly farm electrification adviser with the Talquin Electric Cooperative at Quincy, Fla.

M. Lynne Geiger has accepted a position in product planning work with the Tractor and Implement Division, Ford Motor Company, Birmingham, Mich. His new address is 939 East Fourth St., Royal Oak, Mich. He was formerly a design engineer with The Oliver Corp. at Springfield, Ohio.

Dale A. River is an engineering trainee at the John Deere Waterloo Tractor Works. He was formerly with The Oliver Corp. at Charles City.

John K. Mainey, graduate student in training, Consumers Power Co., Jackson, Mich., has been ordered to active duty in the USAF.

Ivan D. Wood, irrigation engineer, Agricultural Extension Service, U.S. Department of Agriculture, was the recipient of the honorary degree of Doctor of Agriculture at the 1954 commencement of the University of Nebraska last month. This was one of five honorary degrees conferred at the time by Chancellor John K. Selleck.

Ivan D. Wood

Mr. Wood was one of the very first graduates from a professional agricultural engineering curriculum. Shortly thereafter he became agricultural extension engineer of the University of Nebraska and, with the exception of time spent in military service, he served in that capacity from 1914 until 1940. During World War I he saw service in the Signal Corps of the U.S. Army. For a period beginning in 1934, he also served as state (Nebraska) emergency conservation work director. Beginning in 1940 and until 1945 he was district engineer of the Farm Security Administration for seven states. Since 1945 he has been irrigation engineer in the Research Division of the Soil Conservation Service with headquarters at Denver.

During pioneer days, when there was little interest in the fundamentals of soil and water conservation, Mr. Wood stimulated interest and enthusiasm in these subjects to the point that individuals and communities built the first terraces and brush dams. This paved the way for the extensive programs that followed, and in which he continued to participate. In his position as state emergency conservation work director, beginning in 1943, he supervised the organization of 17 U.S. Forest Service erosion control camps, which among other accomplishments, planted 1½ million trees.

He also pioneered much work in irrigation, particularly pump irrigation. His engineering contributions included improved plans for a variety of farm buildings. He personally designed in detail farm homes throughout Nebraska. His publications show 118 titles appearing in farm journals, building-trade papers, and general publications. He is sole or joint author of 31 bulletins and circulars of the University of Nebraska.

Mr. Wood has been an active participant in the affairs of the American Society of Agricultural Engineers since becoming a member. He was one of the early chairmen of the Soil and Water Division, serving in that capacity in 1929-30 and again in 1946-47. He was elected President of ASAE and served during the 1952-53 year. ASAE honored him in 1952 with the award of the John Deere Gold Medal.

Thomas W. Brock has resigned as associate account executive of Fuller & Smith & Ross, Inc., to accept a position with Meldrum and Fewsmith, Inc., Royal Oak, Mich., where he will be working on advertising for the agency's client, Tractor and Implement Division, Ford Motor Co.

Victor L. Hauser, on duty with the U.S. Army, has been transferred to Korea. He expects an interesting tour of duty with the Military Police unit which polices the City of Seoul. His address is PFC Victor L. Hauser, U.S. 54140529, 55th M P Co., APO 301, % Postmaster, San Francisco, Calif.

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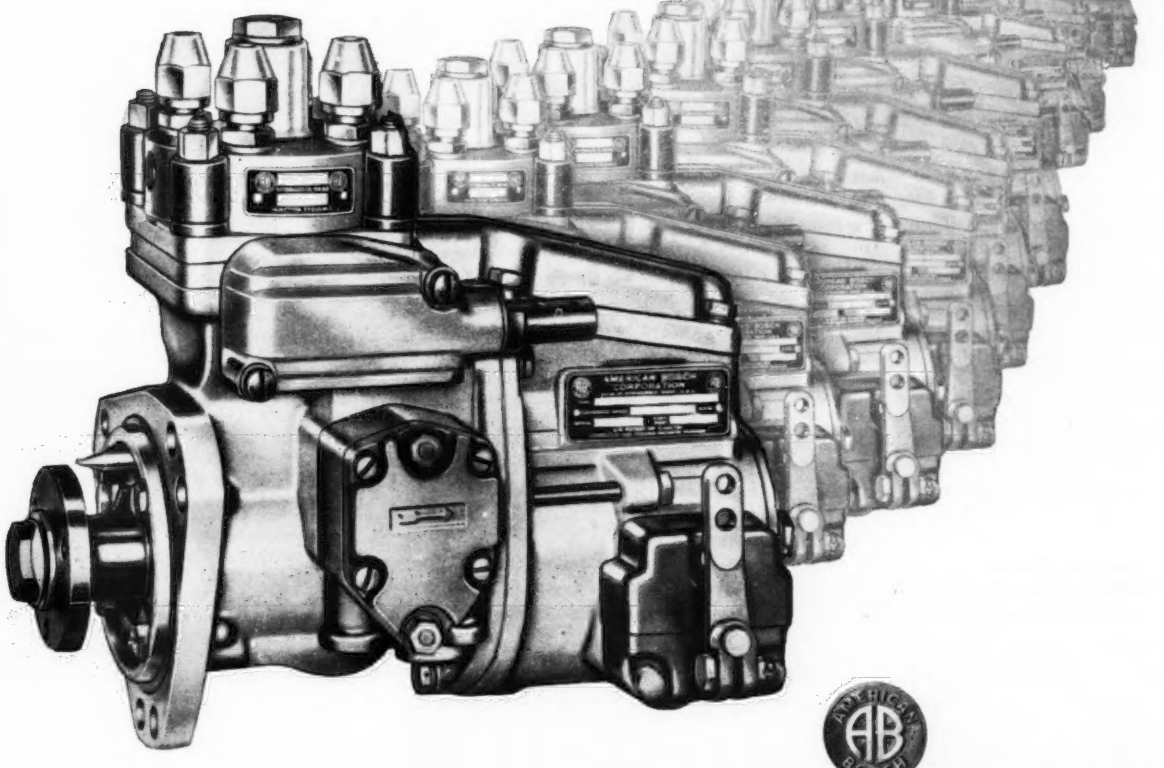

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Adams, John S.—District manager, Bearings Co. of America, 4753 N. Broadway, Chicago 40, Ill.

Anderson, William E.—Engineering specialist (SCS), USDA, 39 N. 6th Ave., Phoenix, Ariz.

Barnes, Billy W.—Student, University of Tennessee (Mail) RR 2, Selmer, Tenn.

Black, William R.—Senior agricultural engineer, Virginia Electric and Power Co. (Mail) Quinton, Va.

Blackwell, Leo — Engineer and estimator, Southern Electric Supply Co., 106 22nd Ave., Meridian, Miss.

Booster, Dean E.—Graduate research assistant, Oregon State College, Corvallis, Ore. (Mail) 845 S. 20th St.

Bouwer, Herman — Research assistance, agronomy dept., Cornell University, Ithaca, N. Y. (Mail) 232 Linden Ave.

Caldwell, Troy L.—Engineering trainee, Ralston Purina Co. (Mail) 1015 Lafayette Blvd., Villa Hgts, Roanoke, Va.

Carter, John R.—U. S. Army (Mail) 162 East Ave,. Hampton, Va.

Coombs, Phillip D.—Student, Oregon State College, Corvallis, Ore. (Mail) 342 S. 10th St.

Croy, Kermit L.—Student, Virginia Polytechnic Institute (Mail) RR 1, Pembroke, Va.

Domier, Kenneth W.—Student, University of Saskatchewan (Mail) Norquay, Sask., Canada

Glass, Wayne S.—Student, Virginia Polytechnic Institute (Mail) 1502 Orange Ave., N.W., Roanoke, Va.

Good, John R. — Irrigation representative, Idaho Power Co., Payette, Ida. (Mail) 1929 3rd Ave., So.

Haasl, Charles M.—Vice-president and general manager, John Deere Plow Co., Chamblee, Ga.

Henson, Keith T.—Student, Oregon State College, Corvallis, Ore. (Mail) 308 N. 17th St.

Jordahl, Martin—Owner, Jordahl Hardware & Electric Co., Manchester, Minn. (Mail) PO Box 117

Kruse, Ernest G.—Student in agricultural engineering, University of Nebraska, Lincoln, Nebr. (Mail) 3831 "C" St.

Longabach, Donald R.—Project engineer, Tractor and Implement Div., Ford Motor Co. (Mail) 207 John M, Clawson, Mich.

Meyberg, William B.—Student, Virginia Polytechnic Institute (Mail) 509 Idlewyld Road, Richmond, Va.

Nave, William R.—Student, University of Tennessee (Mail) Mountain City, Tenn.

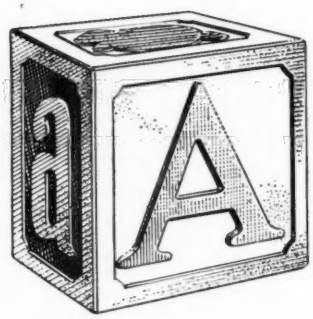
Nelson, Rasmus W.—Drainage engineer, Agricultural Research Service, USDA, 413 Federal Bldg., Boise, Ida.

Ourada, Philip R.—Civil engineer, Corps of Engineers, Alaska District (Mail) RR 3, Boise, Ida.

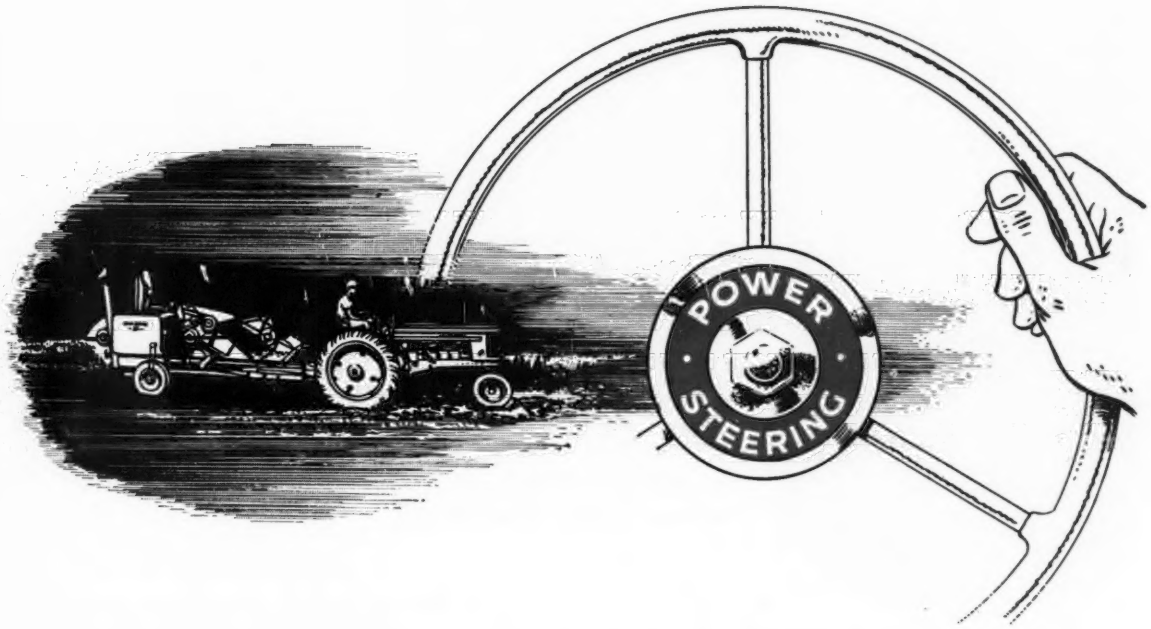
Palmer, John E. S.—Agricultural engineer, Agricultural Engineering Branch, Samaru, (Mail) Newland McColeford, Glos., United Kingdom

Pope, John W. R., Jr.—Student, University of Tennessee (Mail) RR 1, Jackson, Tenn.

(Continued on page 516)



... is for Applause



NOW, as most of us know, the farmer isn't a particularly demonstrative fellow. Which is to say that he accepts most things and events with what you might call a quiet philosophy. And when it comes to making an appraisal—whether it's a heifer or a new piece of machinery—it's a pretty rare farmer who is careless with either his Oh's and Ah's or his flattering adjectives.

Still, every so often some big news comes along—like the announcement of the new John Deere Power Steering—and then even that philosophical armor of his can't hide his enthusiasm. You can detect it easily. For, to the farm equipment man, that gleam of approval in a farmer's eye is as bright as the Milky Way, and his silent nod of satisfaction is as loud as the applause at a Carnegie Hall concert.

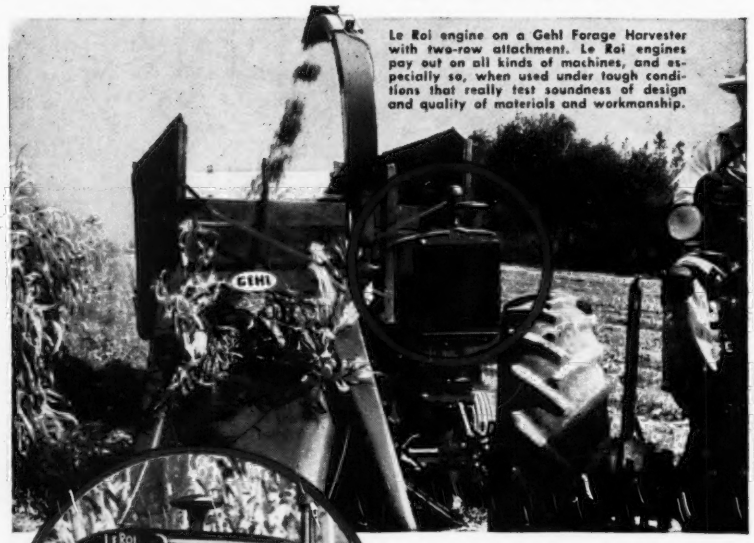
And, of course, it's perfectly natural that farmers everywhere are applauding the announcement of new John Deere Power Steering. It's the biggest news to hit the row-crop tractor field in years. To the farmer it means new freedom from steering effort, new freedom from driver fatigue, and safer, faster, more convenient tractor operation.

Which is all in line with the continuous John Deere policy of supplying the farmer with the quality farm equipment he needs to carry out his operations best at greater savings in time and effort.

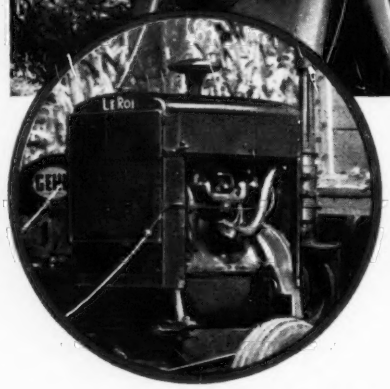
JOHN DEERE • Moline, Illinois

Quality Farm Equipment Since 1837

Tough jobs are easy pickin's for LE ROI heavy-duty power



Le Roi engine on a Gehl Forage Harvester with two-row attachment. Le Roi engines pay out on all kinds of machines, and especially so, when used under tough conditions that really test soundness of design and quality of materials and workmanship.



Built to stand abuse dished out to field equipment without costly breakdowns

LE ROI engines are no automotive lightweight. No, sir. Le Roi builds only heavy-duty engines — power-packed, valve in head engines designed especially for punishing service.

A Le Roi engine is noted for its stamina. Its advanced-design features that mean dependability . . . economy . . . quick field maintenance.

These are a few of the reasons why Le Roi is a leader in the heavy-duty field. They're reasons why you find Le Roi engines powering so many pieces of oilfield, construction, industrial, and agricultural equipment.

There's no doubt about it — Le Roi is your best power buy, whether you're getting new equipment or replacement engines, or whether you're looking for an efficient power plant for the equipment you've designed. Le Roi has a full range of sizes from 15 to 635 hp — for gasoline, natural gas, butane.

Write for bulletins.

LE ROI COMPANY

A Subsidiary of Westinghouse Air Brake Co. E-97

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Plants: Milwaukee • Cleveland — Greenwich — Dunkirk, Ohio • Coldwater, Michigan

Applicants for Membership

(Continued from page 514)

Rich, Glenn W.—Instructor in agricultural engineering, California State Polytechnic College (Mail) 18830 E. Cypress Ave., Covina, Calif.

Sack, Hans A.—Research and design engineer, Clay Equipment Corp., Cedar Falls, Iowa (Mail) 1021 Grove

Saunders, Paul M.—Student, Virginia Polytechnic Institute (Mail) Arrington, Va.

Schlegel, Stuart L.—Ranch shop and equipment foreman, Arthur M. Steintorf Ranch, Firebaugh, Calif. (Mail) PO Box 1038

Schmidt, Ross E. — 2nd Lt. U. S. Army (Mail) Levy, N. M.

Shepard, Frank D.—U. S. Army, Corps of Engineers (Mail) RR 1, Julian N. C.

Stevens, Samuel R. — Student, Virginia Polytechnic Institute (Mail) RFD, Fincastle, Va.

Stewart, Kenneth V., Jr.—State conservation engineer (SCS), USDA, Alexandria, La. (Mail) 1932 Thornton Court

Stout, Wyatt, W.—Salesman of irrigation equipment, Woodin and Little (Mail) 149 Colusa Ave., El Cerrito, Calif.

Talenti, Pier F.—Consulting engineer, University of California, Davis, Calif.

Thomann, Robert M.—Editor, Farm Equipment Retailing, 1014 Locust St., St. Louis 1, Mo.

Throckmorton, Ray I., Jr.—Farm Practice Research, International Harvester Co., 180 N. Michigan, Chicago 1, Ill.

Tovey, Rhys—Student, University of Idaho (Mail) Box 11, Malad City, Ida.

Webb, William H.—Student, University of Tennessee, Knoxville, Tenn. (Mail) Box 148, South Stadium

Zinchuk, Peter P.—Junior engineer, Worthington Corp. (Mail) Box 186, South Windham, Me.

Transfer of Membership Grade

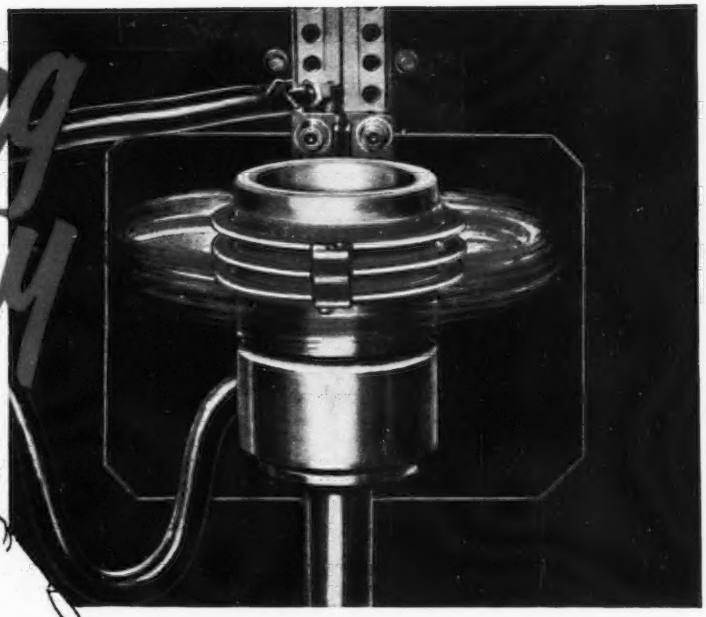
Sutherland, G. R.—Project engineer, John Deere Ottumwa Works, Ottumwa, Iowa (Associate Member to Member)

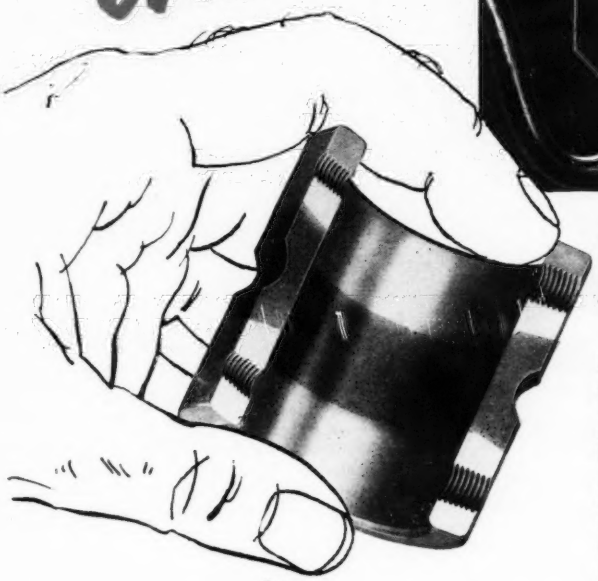
NEW BOOKS

ENGINEERING FOR AGRICULTURAL DRAINAGE, by Harry B. Roe and Quincy C. Ayres. First edition. Cloth, xvii + 501 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., (330 W. 42nd St., New York 36, N. Y.) $7.50.

This is a new text and reference in the publisher's series in agricultural engineering edited by Mr. Ayres. It brings together new information on drainage formerly available only in separate publications and unpublished material, and relates it to older established basic information. Chapters cover: Introduction, Soils in Relation to Drainage, Water Properties of Soils, Rainfall and Runoff, Flow and Measurement of Water, Major Types of Drains and Drainage Problems, Design of Open Ditches, Open-Ditch Construction, Open-Ditch Maintenance, Location and Design of Underdrains; Drain Tiles: Kinds, Classes, Established Sizes, and Standards of Quality, Construction of Underdrains, Drainage of Irrigated Lands, The Soil-Moisture Control Problem on Peat and Muck Lands, Cost of Drainage; Drainage Administration and Law. Appendices present the unit hydrograph method, general design of permeameters, and literature cited.

Blazing the way





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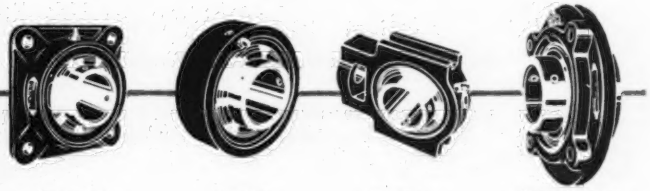

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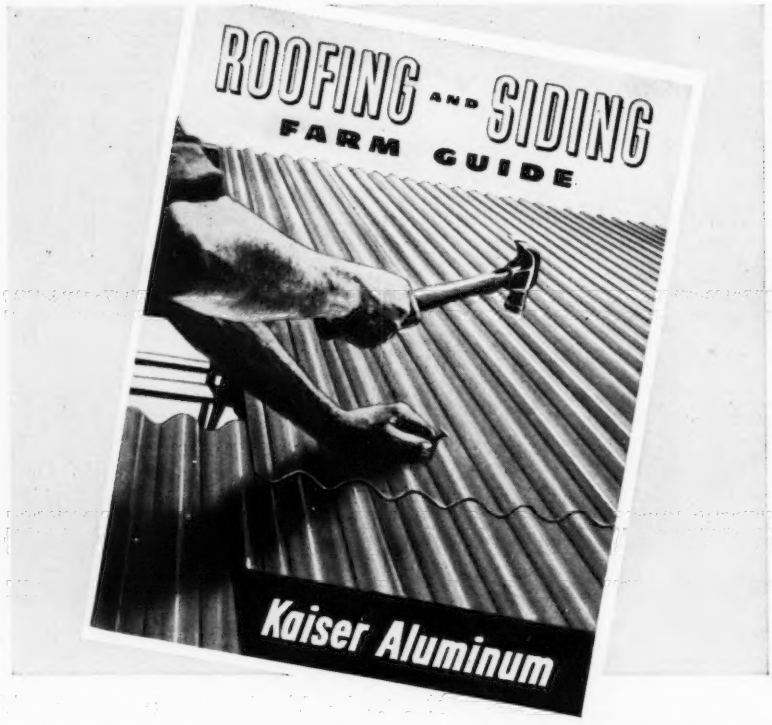

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Helps you show farmers how to profit by proper use of Kaiser Aluminum Roofing!

THE GROWING USE of Kaiser Aluminum Roofing and Siding for farm buildings of all kinds makes the understanding of proper application and construction techniques extremely important to farmers.

This booklet will be a valuable tool in helping you explain to farmers all the advantages of aluminum roofing. Among these advantages are light weight with strength, reflection of hot summer sun, retention of winter warmth, long life with no red rust streaks, no rotting, no warping.

In addition, Kaiser Aluminum Roofing is economical because it is maintenance free, easily applied, never needs paint—yet is permanently attractive.

20 pages of farm building information...profusely illustrated!

• Where to use aluminum roofing, and why • How to estimate requirements . . . including the NEW 48" wide sheets • How to apply aluminum roofing and siding • Loading recommendations • Number of squares in various sheet sizes • Rafter length table • Descriptions of nails and fasteners • Do's and Don'ts of application • How aluminum roofing and siding helps the farmer • Answers to frequent questions about aluminum • Effect of heat on hen health and production, milk production, and hog feed consumption

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The Quality Roofing For Better Farm Buildings

Be sure to indicate the number of booklets you require. Reasonable quantities will be sent without obligation.

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KAISER ALUMINUM & CHEMICAL SALES, INC., 5729 Kaiser Bldg., Oakland 12, Calif.

Please send_____copies of your folder, "Roofing and Siding Farm Guide."

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Organization_____

Address_____

City_____ State_____

NEW PRODUCTS CATALOGS

Double-Pitch Roller Chain

Diamond Chain Co., Indianapolis 7, Ind., announces a complete line of double-pitch conveyor and power-transmission roller chain, which operates over roller-chain sprockets. They are American Standard

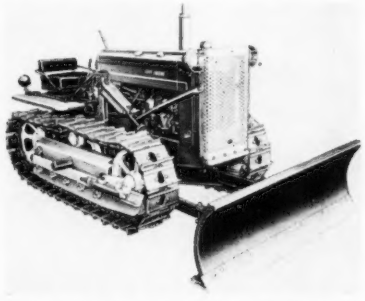
stock chains, and stock attachments are available for the conveyor line. These chains operate over roller-chain sprockets. They are dependable, long life, mediums for light conveying, material handling and moderate-speed power transmission. Catalog No 34 descriptive of these chains will be sent on request to the company.

Farm Building Plans Service

Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, Calif., announces a farm building plans service which provides detailed blueprints for a variety of engineer-designed barns, utility structures and animal shelters, and which offers plans and instructions on how to erect the buildings and also complete bills of materials as required. The plans call for use of lightweight, easy-to-handle aluminum sheets, and they also show the use of aluminum roofing accessories to make the structures weather tight. The plans, available for a $1.00 service fee, include a pole-type general-purpose barn, pole-type stable barn, six-stanchion milking barn, pole-type poultry house, pole-type machinery storage and a pole-type production broiler house.

New Angling Bulldozer

John Deere, Moline, Ill., announces a new angling bulldozer (No. 61) built for use with and to match the power of its "40" crawler tractor. The blade and frame of this bulldozer is of heavy construction and its replaceable cutting edge is ½-in hard-



ened steel. The blade and the moldboard are curved to form a smooth contour that rolls instead of pushes the dirt. The frame is a one-piece welded unit that is claimed not to bend, twist, or sag. The blade can be angled 11½ and 25 degrees to the right or left, or used straight. Angling the blade is accomplished by changing two bolts from one hole to another.

(Continued on page 520)

HELP HIM FARM MORE INTENSIVELY

Show him how to plan production with
PORTABLE SPRINKLER IRRIGATION

You and your local farm equipment dealer can help farmers in your county make more intensive use of their land by getting more production from the same acreage. One of the best and surest ways to promote intensive farming is to help farmers plan production with portable sprinkler irrigation. Crops will get off to a good start and mature faster. Growing seasons will be extended with second and third plantings often possible. These are facts you can prove by pointing out the many farms where planned production, with irrigation, has made it possible to improve crop quality and increase yields . . . and at the same time, insure a steady income.

COMBINE YOUR TALENTS

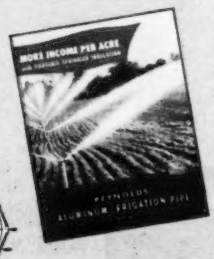
Your agricultural knowledge is a big help in advising farmers on the best sprinkler irrigation practices. With the experience of your local farm equipment dealer who sells Reynolds Aluminum Irrigation Pipe, the two of you can plan a portable sprinkler irrigation system that meets the specific requirements of the farmers you advise.

ACHIEVE YOUR GOAL

Remember—when you work with a dealer who handles Reynolds Aluminum Irrigation Pipe, you work with a man who sells a quality product. Strong, light-weight, rustproof Reynolds Aluminum Irrigation Pipe is the *lifeline* of a reliable portable sprinkler irrigation system. Cooperating, you and the dealer can show farmers in your community how to farm more intensively . . . more profitably on the same acreage . . . with planned production.

REYNOLDS ALUMINUM

Write for your copy of this free booklet on portable sprinkler irrigation systems.



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Reynolds Metals Company, 2588 South Third Street
Louisville 1, Kentucky

Please send "More Income Per Acre," your new illustrated booklet on the application and advantages of portable sprinkler irrigation.

Name_____

R.F.D. or Street_____

Town_____ State_____

New Products and Catalogs

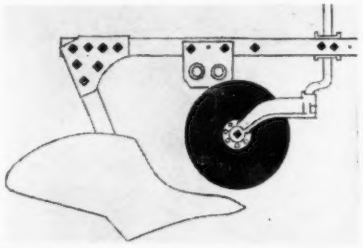
(Continued from page 518)

Taper-Lock Sprocket Catalog

Morse Chain Co., 7601 Central Ave., Detroit 10, Mich., will send on request to interested readers a copy of its new 8-page catalog (C56-54) describing a newly expanded line of Morse taper-lock sprockets now available in a variety of sizes. Prices and sizes are also listed for 1½, 1¾ and 2-inch-pitch type C stock taper-lock sprockets with a hub on both sides. Tables listing prices for Morse packaged roller chains and roller-chain links are included as well as taper-lock bushing installation and removal instructions.

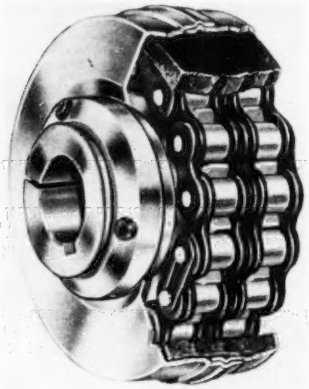
A New Coulter Blade

Crucible Steel Co. of America, Oliver Bldg., Pittsburgh 22, Pa., announces the addition of coulter blades to its line of specialty steel products for the agricultural implement industry. It is a double-beveled, flat, circular blade in the customary C-1080 carbon steel, heat-treated to $^{38}/_{48}$ Rockwell C hardness and varnished or blue lacquered. Currently it is available in solids and cut-outs in sizes 10 to 20 in in diameter. Larger sizes will be made if the demand warrants it.



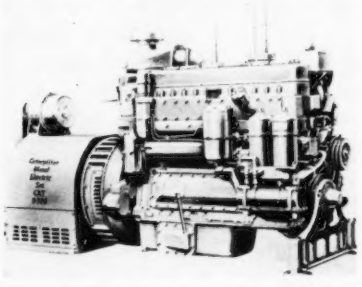
New Flexible Coupling

Cullman Wheel Co., 1344 Altgeld St., Chicago, Ill., has introduced the Gripmaster roller chain flexible coupling designed to connect two shafts, or a motor directly to a machine, and compensate for dissimilar or undersized shafts, slight misalignment and radial thrust. The coupling consists of two hardened steel sprockets, a strand of double-roller chain, two Gripmaster bushings and a snap-on aluminum cover complete with oil-retaining felt. Since the bushings are interchangeable, no reboring alterations are required and all couplings are supplied from stock complete with keyways and setscrews. Five sizes are stocked with bores ranging from ⅜ to 2 in and horsepower ratings from fractional to 200. These bushings can be used with the regular Cullman Gripmaster sprocket line.



Engines and Electric Sets

Caterpillar Tractor Co., Peoria, Ill., announces new higher rpm continuous ratings for Cat D337 and D326 engines and electric sets in both self- and externally-regulated types, for continuous operation 24 hr a day at 1800 rpm. Continuous duty is now available at 1800 rpm for externally-regulated D337 electric sets at an output of 110 kw and for externally-regulated D326 electric sets at an output of 85 kw. Similar operation for self-regulated electric sets is available at an output of 103 for D337 electric sets and 80 kw for D326 electric sets. Under the ratings an output of 162 bhp from D337 engines and 118 bhp from D326 engines is now available for continuous operation at 1800 rpm.



(Continued on page 522)

Water WHERE Needed WHEN Needed

Supplied by Dependable 15 H.P.

WISCONSIN HEAVY-DUTY Air-Cooled ENGINE

Model TFD Wisconsin 2-cylinder Engine, operating Deming Centrifugal Pump, handles complete irrigation assignment on W. Jameson Truck Farm, Avon, Ohio.

Pumping water from pond reservoir to serve permanent pipe lines for irrigating 10 acres of vegetable crops, this Model TFD 2-cylinder Wisconsin AIR-COOLED Engine delivers continuous or intermittent constant-load power, as required, for overhead sprinkling system.

This pumping unit, made by The Deming Co., Salem, O., comprises a Portable Centrifugal Pump, close-coupled to the 2-cylinder Wisconsin Engine. Operating on a continuous service basis, at 80% throttle, working against total head of 140 feet (includes friction), pump will deliver 160 GPM, or 400 GPM against a 60 ft. head (0.35 to 0.88 Acre Inches per hour). When operating on intermittent service load at 100% throttle, pumping capacity is appreciably increased.

Tapered roller bearings at BOTH ends of the extended engine crankshaft (permitting direct-mounting of pump) take up end thrusts and radial loads and Stellite Exhaust Valves and Valve Seat Inserts assure long engine life and minimum servicing.

It takes thorough-going Wisconsin Lugging Power to *stand up and deliver*, on this and many other kinds of heavy-duty power applications . . . as handled by Wisconsin Air-Cooled Engines, in a complete range of sizes from 3 to 36 hp. Write for free copy of 64-page brochure (Form S-150), with condensed specifications and illustrations of more than 260 power applications.

MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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MILSCO BRINGS YOU NEWEST ADVANTAGES IN SEATING COMFORT AND DURABILITY

COMMANDER NO. 1144

With or Without Fore and Aft Attachment

Improved driver-comfort is one of today's major engineering objectives . . . and Milsco can help you to step up the man-work-factor of your equipment with job-fitted cushion seating. Milsco Cushion Seats are the developments of years of experience in designing and manufacturing heavy duty cushion seats for all types of mobile equipment. Our field studies of enduring cushioning materials and contour body support may prove of important value to you. Write us about your seating problem now.

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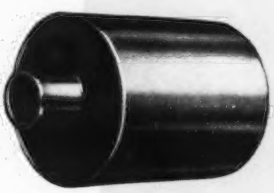
Eliminate Lubrication
Reduce Vibration



Bushings and bearings using the Silentbloc principle correct misalignment and provide torque and oscillating action...*with no lubricating required!* In addition, General Tire Silentbloc mounts are ideal for reducing the jolts and vibration which shorten the life of farm machinery and make maintenance a nightmare.

All Silentbloc applications can be custom designed and produced at our plant in any type metal and rubber. For a quick appraisal of your problem send us your requirements on your company letterhead. For further information just fill out the coupon below.

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☐ Send literature on Silentbloc products
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Company_____ Name_____

Street_____ City_____ State_____

AE-7-54

A High Pressure Pump at a Low Pressure Price!

- **COMPLETE HYDRAULIC BALANCE . . . the exclusive DUAL-VANE Design provides and assures complete balance of all hydraulic pressure loads. You get continuous, maintenance-free operation with increased efficiency at all pressures.**
- **INCREASED OUTPUT . . . machine efficiencies can be increased by 2000 psi pump operation without change of other standard components in the hydraulic system.**
- **CARTRIDGE CONSTRUCTION . . . all pumping parts that move are contained within an easy-to-install cartridge. Pump output can be altered by changing cartridge; servicing is simplified and machine down-time reduced.**
- **ECONOMY . . . the low initial cost and the 2000 psi premium performance of DUDCO PF-100 Pumps can double the value of your *hydraulic dollar.***

Write for DUDCO Bulletin No. DP-302. You'll get the facts on the new PF-100 Series Pumps.

DUDCO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1707 EAST NINE MILE ROAD • HAZEL PARK • MICH.

New Products and Catalogs

(Continued from page 520)

New Forage Harvester

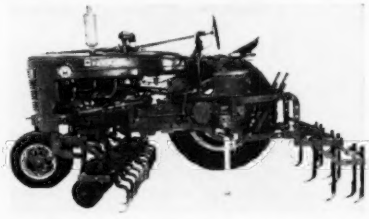
New Idea Farm Equipment Co., Coldwater, Ohio, has introduced a light-weight, all-crop forage harvester with pickup, row crop and direct-cut attachments, and a choice of power take-off or engine drive. The machine has been introduced in limited quantity; full production is scheduled for next year.

The pickup is equipped with adjustable gage wheels and the pickup reel has four retractable bars with six double-spring teeth on each bar. Bearings on pickup bars are

cast housings with greaseless fiber inserts. The pickup drum can easily be removed for replacement of parts. The drive is by use of roller chain. Material from the pickup is removed by an auger which permits a positive even flow of material from the windrow to feed aprons. The flywheel-type cutter head is equipped with four cutting knives, and the design of the knife holders does away with the need to adjust the knives after removal for sharpening. The cutterhead housing has an 8-in width which allows free flow of material to the open-bottom discharge pipe. All working parts of the harvester are protected against overload by a slip clutch, a V-belt or a shear pin. The machine can be furnished with engine or with standard power take-off drive which any 35-hp tractor or larger can handle under normal operating conditions.

Six-Row Vegetable Cultivator

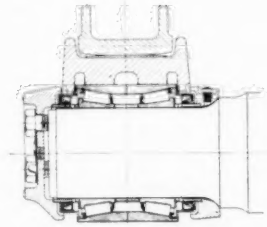
International Harvester Co., Chicago, Ill., has announced a new, heavy-duty, six-row vegetable cultivator designed especially for cultivation of irrigated fields. It is built for use with several different series of the Farmall tractor. The cultivator has two sections; the front section consists of two units, one on each side and may be bolted



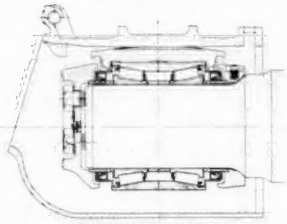
together for operation as a single unit, or they may be operated separately. The implement is adaptable to a wide variety of flat crop or irrigated vegetable growing conditions and will cultivate six single rows spaced 16 to 20 in apart or four rows spaced from 20 to 32 in. Frames of the sections are rigid with parallel-link construction to provide stability for accurate cultivation at any desired depth. A wide variety of ground-tool combinations tailored to fit both crop and soil conditions is available.

New Roller Bearing Application

The Timken Roller Bearing Co., Canton, Ohio, announces a new freight-car journal bearing application, which reduces the initial cost of roller bearings for freight cars, which eliminates the necessity of a journal box, and which better utilizes available space



Pedestal type side frame



and integral box side frame

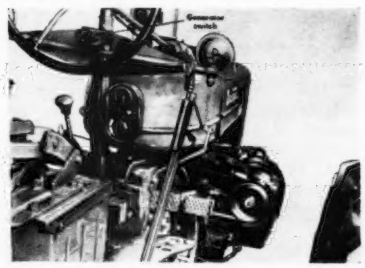
thereby resulting in an improved bearing design.

Lending itself to high-speed automatic production, this new bearing has been standardized so that parts within the bearing application can be interchanged. It is a heavy-duty application suitable for any type of freight-car service. It can be used with both integral box-type side frames commonly used on existing friction-bearing-equipped freight cars and pedestal-type side frames used on new roller-bearing equipped cars.

The new design is said to incorporate all the advantages of roller bearings in freight cars such as the reduction of starting resistance by 88 percent, reduction of lubrication inspection by 90 percent, and reduction of lubrication costs by 89 percent.

Tractor Has Electric Generator

International Harvester Co., Chicago, Ill., announces an experimental electric-generating system to be mounted on a farm tractor, making it a mobile source of electric power, as well as of mechanical power for general farming operations. Called the "Electrall"



system, the electric generating unit is mounted on a current model of Farmall tractor. It is also being applied experimentally to motor trucks for farm and industrial use. This new combination gives promise of developing new techniques in the application of power to agriculture.

With this unit, electric power can be used to operate farm machines pulled by a tractor and also for operating portable electric tools,

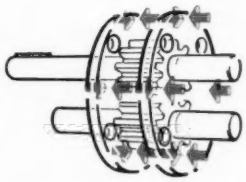
Back of the JOHN DEERE No. 55 Combine is a story of . . .

Oil Power

HYDRECO

Oil Power

The famous HYDRECO Four-Bolt design Hydraulic Pump provides Oil Power on the John Deere No. 55 Self-Propelled Combine to position the Auger Platform and control the Variable Speed Drive. This model 1506 Pump delivers 3.3 gpm at 1200 rpm with pressures to 1500 psi . . . other models to 130 gpm.



***Pressure Balanced* wear plates maintain a fixed clearance between wear plates and gear faces regardless of pressure. This feature in HYDRECO Pumps and Motors minimizes oil slippage and power loss . . . volumetric efficiency and mechanical efficiency remain high!**

Build the hydraulic circuit around the dependability of HYDRECO components. More and more design engineers find this premise leads to successful performance in service whether the application be farm equipment, machine tools, materials handling or construction machinery.

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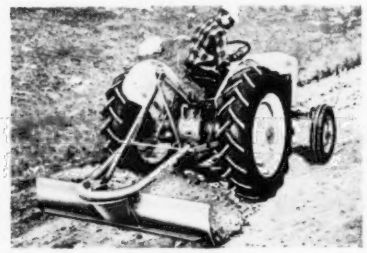
or provide special or temporary lighting installations. It can also be used, within its capacity, as a temporary source of power for lighting, appliances, pumps, milking machines and other electrical equipment. This unique combination of electric and tractor power seems to offer unique possibilities.

Earthmoving Blade

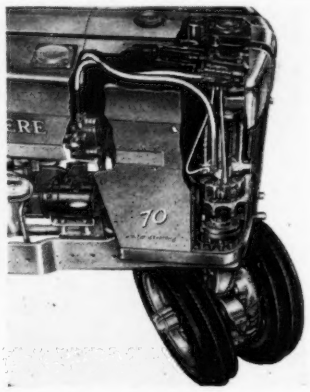
Tractor and Implement Div., Ford Motor Co., Birmingham, Mich., announces a new blade designed to handle a wide variety of work such as ditching, terracing, leveling, backfilling, snow removal, barn and feedlot cleaning, and other jobs. The six-foot moldboard or blade has cutting edges on both top and bottom and can be reversed to



use either edge. The blade can be angled 45 degrees in either direction, can be offset in two positions to the right or two to the left, and can be reversed for backfilling. Blade pitch is adjustable to any one of four positions. The blade is lifted and lowered by hydraulic control and weighs 268-lb. It is 13½ in high and is made of ¼-in heat-treated steel. The frame is of one-piece construction of 2½-in standard-weight tubular steel.

Tractor Power-Steering Unit

John Deere, Moline, Ill., announces that a new power-steering unit is now available as optional equipment at extra cost, on its new 50, 60 and 70 model tractors. The unit is



an integral part of the tractor — not an attachment.

The power-steering unit operates whenever the tractor engine is running. A constantly running gear-driven pump supplies hydraulic pressure through a control valve to actuate a steering vane attached to the steering spindle. The vane is enclosed in a cylinder concealed between the radiator and grille and located close to the front wheels where the effort is needed. Turning the steering wheel to right or left actuates the control valve, directing oil under pressure to the hydraulic cylinder, where it rotates the vane and turns the front wheels at the operator's command.

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — 1954 — JANUARY—O-488-549, 491-550, 494-551. FEBRUARY—O-19-602. MARCH—O-65-603, 66-604, 67-605. APRIL—O-90-613, 98-614, 106-615, 102-616, 116-617, 134-618. MAY — O-131-619, 149-620, 150-621, 151-622, 155-623, 108-624, 162-625, 173-626. JUNE — O-180-627, 181-628, 197-629, 198-630, 182-631, 200-632.

POSITIONS WANTED — 1953 — DECEMBER — W-405-80. 1954—JANUARY—W-456-88. FEBRUARY—W-5-102, 20-103, 46-108. MARCH—W-56-112, 54-113, 37-116. APRIL—W-84-120, 96-122, 93-123, 109-124, 124-125, 125-126, 107-127. MAY—W-122-128, 146-129, 128-130. JUNE—W-115-131, 159-132, 164-133, 169-134, 141-135, 179-136, 199-137.

NEW POSITIONS OPEN

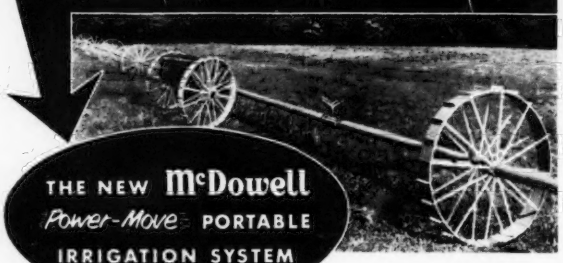
AGRICULTURAL ENGINEER, assistant professor rating, to teach rural electrification and related subjects in a land-grant college in the South. BS and MS deg in agricultural engineering, or equivalent. Usual personal qualifications for college teaching. Normal opportunity for advancement. Summer teaching or research if desired, at one-fourth extra annual salary. Opening effective Sept. 15. Salary $4200 on 9-mo basis. O-204-633

GRADUATE ASSISTANTSHIPS (three open Sept. 1; two additional in January 1955), teaching or research, any technical branch of agricultural engineering. Southwest location. Graduate study up to 10 semester hours. BS deg in agricultural engineering, or equivalent. Usual personal qualifications for college teaching and research. ECPD accredited curriculum. Salary $1250 for 9 mo. O-205-634

GRADUATE RESEARCH ASSISTANTSHIP on feed handling, grass silage, and grain storage in a northwestern land-grant college. Op-

(Continued on page 526)

Mechanized Sprinkler Irrigation On Wheels!



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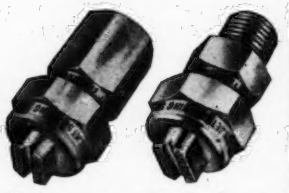

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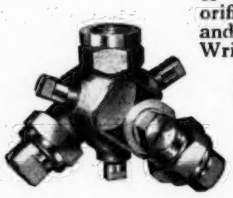

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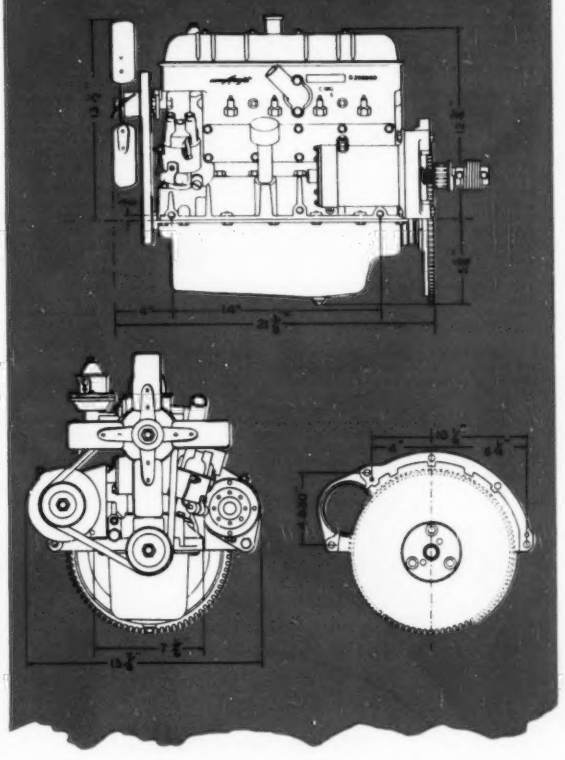
THE MOST ECONOMICAL, DEPENDABLE 25½ H. P. ENGINE EVER PUT ON A PIECE OF FARM OR INDUSTRIAL EQUIPMENT



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the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong". Wear it.

STYLES AND PRICES OF ASAE EMBLEMS

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With red ground for Affiliates — furnished only in pin with safety clasp — $3.50 each.

Send orders to ASAE, St. Joseph, Michigan.

Personnel Service Bulletin

(Continued from page 524)

portunity for 9 mo teaching in power and machinery in second year, beginning September 1955, while present staff member will be on sabbatical leave. BS deg in agricultural engineering, or equivalent. Interest in and qualification for career in school work in land-grant college. Salary $1500 first year; second year open, depending on qualifications. O-207-635

DESIGNERS (2) for various phases of engine and equipment design with leading tractor and heavy equipment manufacturer in Midwest. Opportunity for personal growth and development with a growing organization with a line of products which enjoy an excellent reputation throughout the world. Age up to 50. Engineering graduate or equivalent. Experience desirable in design and development work and manufacturing. Intelligence, good health, and ability to work with people. Mechanical aptitude and knowledge of engineering principles. Salary open. O-209-636

AGRICULTURAL ENGINEERS for staff research positions, and graduate research assistants for each of three fields—food processing, forage mechanization, and poultry housing, in a land grant university in New England. MS deg desired for staff positions, BS deg in agricultural engineering, or equivalent, satisfactory to Graduate School for graduate research assistants. Usual personal qualifications for research in public service. Ratings for staff positions depend on qualifications. Staff position in food processing offers opportunity for work toward Ph.D. Staff position in forage mechanization requires man with training in soil moisture relationships and in machine design. Good opportunity for advancement. Salary open for staff positions, about $2300 for graduate assistants. O-208-637

ASSISTANT OR ASSOCIATE ENGINEER on staff in the agricultural engineering department of a land-grant college in the Southwest. Primarily research in the field of irrigation and hydrology. Deg in either agricultural or civil engineering and practical experience in the irrigation field is preferred. Permanent position, 12 mo basis with one month vacation. Age 30 to 40. Salary $5000 to $6000, depending upon experience and training. O-219-638

AGRICULTURAL ENGINEER for research and development work on heavy equipment with leading manufacturer in Midwest. Age 22-32. BS deg or higher in agricultural engineering. Intelligence, good health, and inherent desire for research and development work. Opportunity for personal growth and development with growing organization with well-established line of products. Salary open. O-222-639

AGRICULTURAL ENGINEERS (2) and RESEARCH FELLOW for work in an East Coast land-grant university. One opening in extension; one full-time and one fellowship in research primarily in crop conditioning. Usual qualifications for public service work. BS deg in agricultural engineering or equivalent, higher desirable for full-time positions. Good opportunity for advancement. Salary $4400-6500 on 12 mo basis for full time, depending on qualifications. $1440 for research fellow. O-223-640

AGRICULTURAL ENGINEER, research assistant, with part-time teaching if desired, in a land-grant university in New England. Research in poultry house ventilation and mechanization. Teaching in power and machinery. Age under 35. BS deg in agricultural engineering, or equivalent, MS deg preferred. Interest in research. Experience with ventilation and farm machinery desirable. Above average opportunity in expanding research program. Location in rural area but close to larger cities in Northeast. Excellent retirement system. Salary open. O-214-641

AGRICULTURAL ENGINEER for irrigation engineering research in a land-grant college in the Southwest. MS deg in agricultural engineering, or equivalent, with interest and specialization in irrigation engineering. BS deg may be acceptable, with good scholastic record, experience, and farm background. Full-time new position being added to the department. Annual leave 24 days. Established retirement, health, and accident provisions. Applicants must furnish transcript of credits and adequate reference. Application forms and further information on request. Salary $4764. O-231-642

AGRICULTURAL ENGINEER, extension specialist in irrigation and drainage, in a southwestern state. Additional general extension work in farm structures and farm power and machinery. MS deg in agricultural engineering, or equivalent. BS deg may be acceptable with good scholastic record, experience, and farm background. Full-time position. Annual leave 24 days. Established retirement, health, and accident provisions. Applicants must furnish transcript of credits and adequate reference. Application forms and further information on request. Salary $4764. O-232-643

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for sales, service or management in power and machinery, farm structures or soil and water field, with industry. Any location. Some travel satisfactory. Married. Age 32. BS deg in agricultural engineering, 1949, University of Minnesota. Farm background. Electrical instrument mechanic one year in military service. Irrigation and soil conservation experience 3½ yr in design and supervising installation of sprinkler systems and pipe lines; land levelling and layout of irrigation and drainage ditches; supervising construction and surveying crews. One year in mechanical engineering on calculation and layout of drives for variable speed clutches, including calculation of belt and chain drives, and horsepower and torque capacities. War non-commissioned service in Air Force over 3 yr. Available on 30 days notice. Salary open. W-177-138

AGRICULTURAL ENGINEER for design, development, research or teaching in power and machinery field in industry or public service, preferably in Southeast. Married. Age 26. No disability. BS deg, 1949; MS deg expected August 1954, both in agricultural engineering at North Carolina State College. Farm background. Field engineer 2 yr. Farm manager 2 yr. Available Sept. 1. Salary open. W-189-139

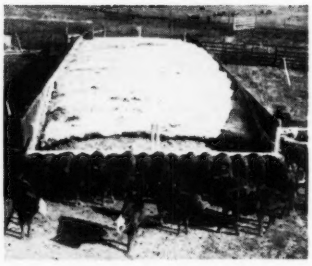
AGRICULTURAL ENGINEER for design, development, research, extension, or service in power and machinery field with experiment station, manufacturer, distributor or farming operation in Central or Midwest area. Will travel, preferably in one-state area. Single. Age 26. No disability. BS deg in agricultural engineering, 1952, University of Nebraska. Farm background. Laboratory assistant in farm motors course 4½ mo. Maintenance of Army engineer equipment, 16 mo. Currently GS-5 engineer with SCS, applying soil conservation practices in pilot watershed project. Reserve commissioned service in Corps of Engineers, 22 mo. Available on three weeks notice. Salary $4000+. W-206-140

(Continued on page 528)

How to Build

Feed-Saving, Low Cost Silos with SISALKRAFT

Temporary Upright Silos — Sisalkraft is used to line the sides of wire or wood fencing. Can be built in ten easy steps. Write for instruction folder.



Stack or Box Silos — Feed stored on hard-surfaced floor with reenforced walls. Top completely covered with Sisalkraft in 5, 6 or 7 foot widths.

Tough, waterproof, airtight Sisalkraft protects feed from air, rain, and sundamage. Its steel-strong reenforcing makes it sturdy, hard to tear, long-lasting, low cost building material. Here are examples:

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The personal interest of executives like Mr. Steudel, and the systematic bond purchases of more than 8,000,000 enrolled Payroll Savers are reflected in the following figures:

- In March, 1954, purchases of U.S. Savings Bonds, Series E and H, by *individuals* reached $474 million, highest March figure in 9 years—a gain of 20% over March, 1953.
- Purchases of E and H Bonds, by *individuals* during the first quarter of 1954, totaled $1,380 million—the highest for any quarter since 1945.
- The *cash value* of Series E and H Bonds held by *individuals* at the end of March, 1954, was $37 billion, 175 million—the highest in the thirteen year history of the Savings Bond program.
- Payroll Savers are serious savers: over 75% of the amount of Series E Bonds that matured since May, 1951—almost $9 billion—is still being held by individuals under the Treasury's 10 year optional automatic extension plan.
- For the third straight month of 1954, sales of E and H Bonds exceeded maturities and redemptions. The sales excess amounted to $242 million on March 31—the highest first quarter net since 1950.

If employee participation in your Payroll Savings Plan is less than 50%—or if your company does not have a Payroll Savings Plan, get in touch with Savings Bonds Division, U.S. Treasury Department, Washington, D.C. Your State Director, U.S. Treasury Department, will be glad to help you install a Plan and build employee participation.

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Personnel Service Bulletin

(Continued from page 526)

AGRICULTURAL ENGINEER for sales or field service on mechanical hydraulic equipment, with manufacturer or other private industry in Southeast, Southwest, West, or foreign location. Married. Age 33. No disability. BS deg in agricultural engineering, 1950, University of Florida, with 12 technical electives in mechanical engineering. One graduate course in hydraulics and fluid mechanics. Farm background. Experience as electrician 3½ yr. Sales engineering experience on pumps, irrigation equipment, internal combustion engines, power transmission and miscellaneous supplies in agricultural fields. War non-commissioned service in Air Force 3 yr. Available August 1. Salary open. W-224-141

Professional Directory

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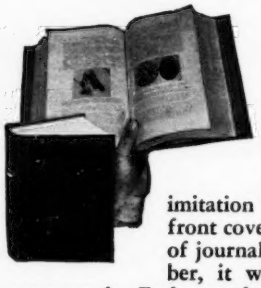

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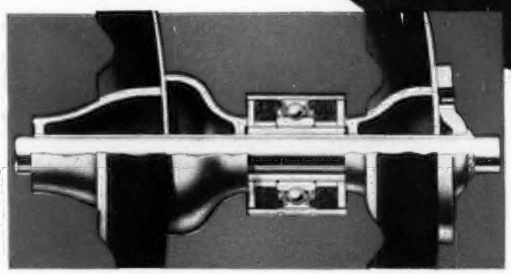
NEW DISC HARROW SPECIFIES NEW DEPARTURES



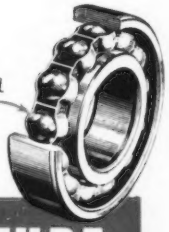
Sealed-for-Life **ball** bearings, pioneered by New Departure, are used in Allis-Chalmers' new grease-packed bearing assembly as standard equipment in their No. 30 disc harrow.

Built for heavy-duty farming! That's Allis-Chalmers' No. 30 disc harrow. And you'll find New Departure Sealed-for-Life bearings supporting the disc-gangs!

These outstanding **ball** bearings have been proved throughout the farm field. They seal lubricant in—dirt out. They carry all loads—radial, thrust or combination. And these New Departure Sealed-for-Life bearings are virtually maintenance-free!

When you design for the farm, talk with New Departure engineers.
Their experience is always *at your service.*

NOTHING ROLLS LIKE A BALL

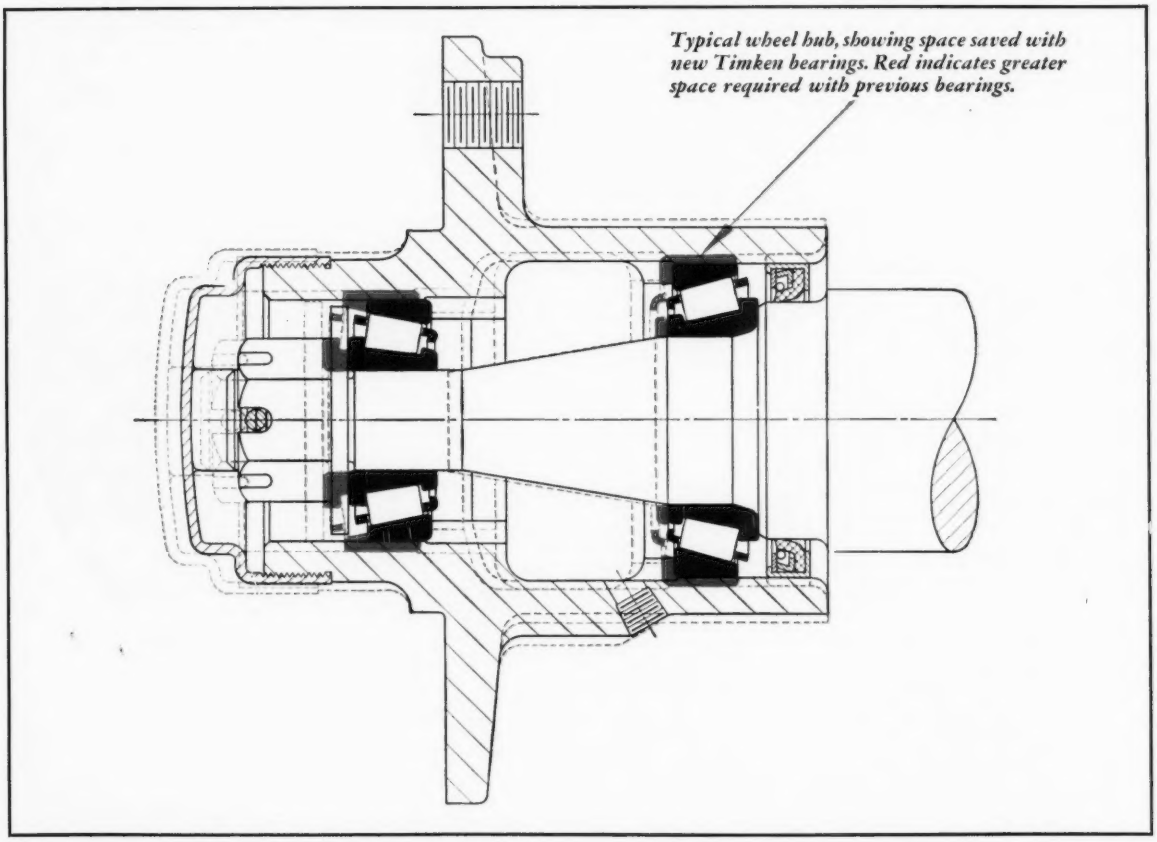


NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Plants also in Meriden, Connecticut, and Sandusky, Ohio
In Canada: McKinnon Industries, Ltd., St. Catharines, Ontario

EVERY MAKE OF FARM TRACTOR HAS TIMKEN BEARINGS: MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!

New Timken® bearings cost 7.1% less per wheel, save still more on related parts!



Typical wheel hub, showing space saved with new Timken bearings. Red indicates greater space required with previous bearings.

TWO new Timken® tapered roller bearings, ¾″ and 1¼″ bore respectively, not only offer a 7.1% saving on wheel bearing costs, but also make it possible for you to design savings into related parts.

These savings are possible because the new-design bearings are shorter in width and smaller in outside diameter than previous Timken bearings with the same bore sizes.

The wheels of small tractors—one of the applications for which the new bearings are suited—offer a good example of how you can save money. The hub can be designed to require less metal and machining. The seal, being smaller, can cost less. Less grease is used in factory-lubricating the bearing. And the spindle can be made shorter, with less machining required.

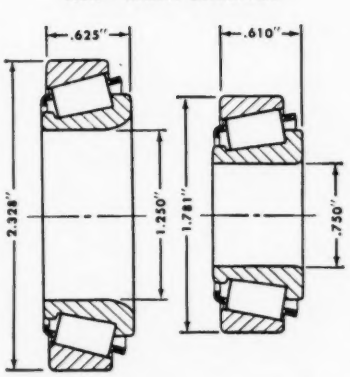
Other applications for which the new Timken bearings have ample capacity include gear boxes and idler shafts in small tractors, balers, wagons, corn pickers, disc harrows and other implements.

It was Timken Company research and engineering that made the new bearing possible. Over the years we have pioneered many important advances in steel, surface finish and design of tapered roller bearings—all of which contributed to this latest achievement.

For full information on the new Timken bearings, call your Timken Company representative or write: The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

PROFILE AND BASIC DIMENSIONS OF THE TWO NEW TIMKEN BEARINGS



NOT JUST A BALL ◯ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⬯ AND THRUST →◫← LOADS OR ANY COMBINATION →◫←